IV.

PHYSICAL GEOGRAPHY OF THE NORTH-WESTERN BOUNDARY OF THE UNITED STATES.

By George Gibbs.

WITH TWELVE ILLUSTRATIONS.

READ NOVEMBER 11th, 1869.

Geology of the Coast Region — Changes of Elevation.

Dr. Newberry, who has carefully studied the geology of the Sierra Nevada, the Cascades, and the Coast range, both in California and Oregon, has arrived at the following conclusions: That, in the earlier stages of elevation of the continent, the Sierra Nevada and the Cascades of Oregon formed its western limit, and that long before the elevation of the Californian and Willamette valleys, or of the Coast mountains, the ocean broke against their sides; that this was the case prior to the tertiary epoch, as no rocks so recent as the tertiary are found upon their summits, or high up on their flanks; but that, as the elevation of the continent and of these ranges progressed, the rocks of the miocene were deposited, the edges of which rest against their base; that the upheaval of the Coast range was still subsequent, those mountains being formed by the protrusion of igneous rocks through the miocene, which yet partially crowns and skirts them on either side; that the elevation proceeded until the glacial epoch, during which the great erosions of the valleys, the

straits, and river bottoms, as well as of the northern fiords, took place, after which a subsidence commenced, when the drift was deposited; and that finally a new upheaval commenced, and is still progressing.

These deductions are fully borne out by the facts collected in Washington Territory. From the Columbia, at the mouth of the Cowlitz, tertiary sandstones line the basin included between the Coast and Cascade ranges, as far as Bellingham Bay on the east and Port Townshend on the west, and have been traced consecutively along the Pacific, from the mouth of the Columbia to Cape Flattery, and through the southern shore of the Strait of Fuca. These rocks are almost everywhere greatly disturbed by intrusions of trap, and, except along the edges, are covered with drift. They abound in coal, of which seams of various thicknesses have been found in many localities. None of the earlier stratified rocks have as yet been detected below the tertiary, upon the mainland of Washington Territory; but the occurrence of cretaceous and carboniferous fossils elsewhere in the neighborhood will presently be mentioned.

Lower Columbia River.

The features of the country on the Lower Columbia have been described by Mr. Dana in the Geology of the Exploring Expedition, and by Dr. Newberry and myself in the Pacific Railroad Reports,* and little can now be added to the facts there stated. The estuary of the Columbia River extends to Cathlamet Point, about twenty-five miles from Cape Disappointment. Its greatest width is seven miles. Much of this space is occupied by sand, the deposit of its freshets, and these extend to some distance seaward outside of the heads, forming the dangerous obstructions to its entrance. During the freshets, which commence about the middle

* P. R. R. Reports, vol. i and vi.

of May and continue till near the end of July, immense quantities of this deposit are brought down. The bulk in each gallon of water is perceptible, and so vast is the flood, that the water on the bar is drinkable at low tide. The northern point of the entrance, known as Cape Hancock or Disappointment, is a precipitous, rocky bluff, connected with the main by a strip of land elevated but slightly above the sea, which divides the Columbia from Shoalwater Bay. The southern, Point Adams, is of sand, and forms the extremity of the so-called Clatsop Plains. These are rather a series of parallel valleys, inclosed between ridges of sand, which extend from the mouth of the river to Tillamooks Head. The extensive sheets of water, north of the Columbia, known as Shoalwater Bay and Gray's Harbor, resemble the estuary of that river, in their general character. Both are protected from the sea by shelter beaches, probably formed in great measure from the matter swept down by the waters of the Columbia, and are in great part silted up by deposits of sand and mud.

At Astoria the sandstones and shales of the tertiary are intersected by dikes of basalt, and a similar dike occurs on Shoalwater Bay. Fossils, ascribed by Mr. Conrad to the miocene, are common, chiefly occurring in calcareous nodules washed from the banks. They comprise cetacean bones, fish, mollusks, echini, and one species of abies.* Above Astoria the rocks exposed on both shores of the river are chiefly basalt, and basaltic conglomerate in horizontal beds, and interstratified. The basalt is generally compact, and in places assumes columnar and nodular forms, though less distinctly so than east of the Cascades.

The conglomerates vary greatly in composition from tufaceous and pebbly rocks to one imbedding large fragments of basalt. Mr. Dana has shown that they are

* Geology Expl. Exp., App., p. 722.

sometimes interstratified with, and even merge into, the tertiary sandstones.

Cowlitz and Chihalis Basin.

Leaving the Columbia for Puget Sound, the rocks bordering the Cowlitz and Upper Chihalis are again tertiary, interrupted as before by dikes of basalt, which become, however, less extensive and frequent. Several outcrops of coal occur in the neighborhood. One seam of eight feet in thickness was recently discovered upon a creek emptying into the Columbia below the Cowlitz. On the Cowlitz River, near the landing, and again about half a mile above the upper forks, are others. Upon the "Skookum Chuck," an easterly branch of the Chihalis, still another seam was opened some years ago, but the coal, though abundant, proved of inferior quality. The exact limits of this formation, owing to the broken and heavily-timbered face of the country, have nowhere been defined. It undoubtedly extends west, with interruptions of basalt, through the Willopa hills to Shoalwater Bay and Gray's Harbor; but its eastern border does not probably reach beyond the foot hills of the Cascade range. As in the Willamette valley, it has evidently been much denuded.

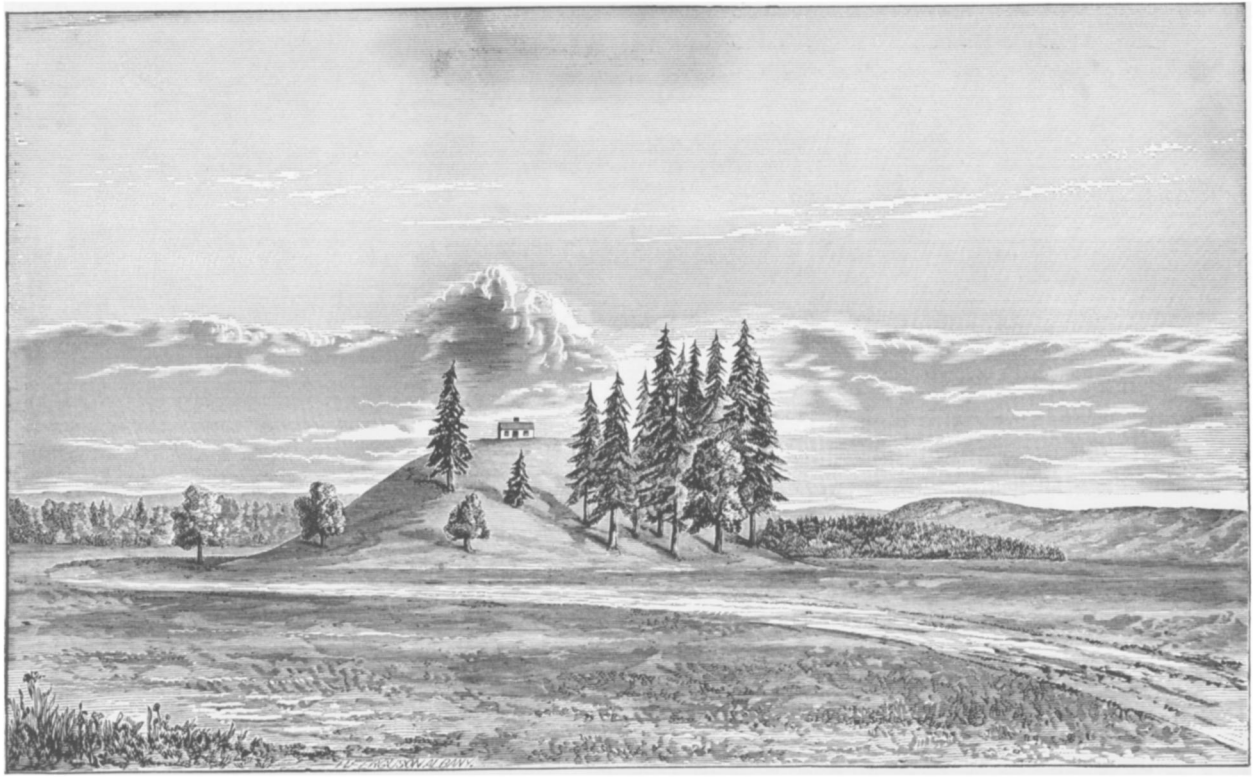
The soil on the Cowlitz River, where the face of the country is not too broken for agricultural purposes, is among the richest in the territory, consisting of a light sandy loam of great depth, with interrupted beds of clay, wet and excessively tenacious like those of the Willamette. On reaching the Skookum Chuck, a series of gravelly prairies intervenes, which extends along the eastern side of the sound to beyond Steilacoom. On the Lower Chihalis and Gray's Harbor, and upon the streams entering Shoalwater Bay, tracts of great fertility again occur.

Mound Prairies.

The gravelly prairies between the Skookum Chuck and Olympia are characterized by the occurrence, in great number, of small elevations, which have given to them the descriptive name of the mound prairies. They occur elsewhere, but more sparingly in different parts of the country; always, so far as my observation has extended, in gravelly deposits, and in such situations as may be supposed to have been lake bottoms, for I presume those upon the hills, above the Dalles of the Columbia, to be of a different character, as they are different in size and shape. The prairies upon which these mounds occur lie upon both the Chihalis and the Tenalquet, the former emptying into Gray's Harbor on the Pacific, the latter into Budd's Inlet, an arm of Puget Sound, their valleys being separated by low, rolling hills. There is every evidence of their having once been lakes. The hills bordering them exhibit sloping banks, such as generally surround tranquil waters, and upon several there are more or less distinct lacustrine terraces.

So strongly, indeed, do they suggest this origin, that the Indian legends tell of their being dried up by supernatural means. A noticeable feature among all of them is, that the ground is rather lower around their edges, or immediately under their banks, than in the centre, as is the case sometimes with marshes.

The first prairie of the series is that known as Ford's, situated on the north bank of the Skookum Chuck, and here the mounds are first observable. On this tract they are low, and not sufficiently numerous to attract particular attention. It is nearly a dead level, and raised but little above the freshets of the Chihalis. At Luark's, along the edge of the woods, on the east side, numerous "oak stubs" grow on small hillocks, which seem to have been raised partly by their droppings, partly from the pushing up of the soil by their accumulated roots; but these are not to be classed with the true mounds. On the



THE GRAND MOUND.

"Grand Mound prairie," there are low, scattered mounds between Cooper's and Goodell's, the most distinct being those nearest the woods. What is called the "Grand Mound" itself, is an isolated hill about sixty feet in height, on which are a number of oaks and large firs. Its most gradual slope is to the north-west. No rock is visible on any part of it, but there is a spring on one side, about two-thirds of the way up. It is, of course, entirely distinct from the mounds in question, though its form has doubtless been modified by water. Around and to the north of the Grand Mound the lesser ones are very indistinct; but through the middle of the prairie they become more numerous and better defined. They seem most so, however, near the edge of the prairie, at least on the south-east side, where the road passes, and toward the eastern end they are well developed. They are generally covered with fern, denoting a better soil than that of the prairie level, which is very gravelly and poor. Boulder stones begin here to be common, between the mounds. Crossing "Scatter Creek," a stream which wanders over the level of the prairie, often during the dry season disappearing and rising again; the next, called the "Long prairie," is pretty well covered with mounds. It is more unequal in elevation than the last; and at the eastern end there is a terraced ridge in the middle, about twenty-five feet high, having a steep bank to the south. On this there are some few mounds of an exceptionally large size, the highest, about fifteen feet, having been the site of an Indian house, or perhaps Kamass cellar, several holes being excavated in the summit. The ground is here very stony, the boulders being sienite, trap, green-stone and trap conglomerate. The ordinary mounds are pretty distinct, say four or five feet high.

On Hodgden's prairie the mounds are obscure. A terraced ridge runs through its middle, and there are a great many boulders of a foot or eighteen inches diameter

scattered through it. At Hennesey's a well of fifteen feet was dug entirely through boulder stone, no walling being required. The little "Round prairie" beyond is more sandy than gravelly, and quite free from mounds. The two prairies on Black River, known as Baker's and the Mimee prairie, I did not visit, but received satisfactory information from others respecting them. On the first, the mounds are comparatively few and low. The southern end of Mimee prairie is said to be terraced with but few mounds; the northern end thickly covered with mounds about six feet high. The country on Black River is in great part swamp, caused by beaver dams.

The most remarkable development of this formation, however, is on Rabbison's or "Stony prairie," which lies on the Tenalquet. Nearly the whole extent is so thickly studded with mounds, that the bases touch one another. The average height is six feet, and they are generally twenty-five or thirty feet in diameter, being sections of a sphere. Quite a number of them have been opened from curiosity, and in every case with the same result. They are composed of a light soil, with interspersed gravel, being perfectly homogeneous through the whole mass. I caused one of them to be trenched down to the level of the prairie. There was no appearance of stratification. The soil and gravel were equally intermixed throughout. This prairie is of generally uniform level, though with some swales running across it, and the intervals between the mounds are, as it were, paved with boulder stones; the appearance presented being as if the superficial soil, down to this bed, had been shovelled up into piles. The mounds are covered with grass and fern, the intervals, as mentioned, being stony, barren, and destitute of vegetation. Beyond this prairie they extend a short distance into the woods, a fact which I have observed nowhere else. They have, however, no resemblance to the hillocks caused by fallen timber. "Bush's prairie" is sandy, and exhibits few or no traces of

mounds, so far as I noticed. The above constitute the district of the mound prairies proper, but there are also traces on some of those lying between Olympia and the Nisqually River, and on parts of the Nisqually or Steilacoom Plains. These are generally low and indistinct, but characterized by the same superiority of soil.

Captain (now Admiral) Wilkes, in his journal of the United States Exploring Expedition, speaks of the "Butte prairies" as covered with tumuli, or small mounds, at regular distances asunder, conical in form, about thirty feet in diameter at the base, and six or seven above the general level. He opened some of them, but found nothing except a pavement of round stones. They seemed to him to be grouped in fives (thus ⁘), and, he remarks, had evidently been constructed successively, and at an interval of several years, and were formed by scraping the surface-soil together.

Among the various theories respecting their origin, I had met with none that appear to me satisfactory. Capt. Wilkes, as shown above, is decidedly of opinion that they are of artificial, and, inferentially, human, construction. To this there are many objections, however. The Indians themselves have no tradition of their origin, and clearly do not recognize any marks of human labor, or they would doubtless have referred them to the ancient or demon race, whose handiwork is apparent in everything anterior to their own traditional recollection. The solution which occurred to the minds of those of whom I inquired was that they were made, like the waves of the sea, by winds. That they are not properly tumuli is apparent from the fact that they contain no bones or relics of any kind, or evidences of fire. Their number also contradicts the supposition, as does likewise the other fact, that there are none conspicuous above the rest, which would have been the case with the graves of chiefs. Except for sepulchral purposes, I can conceive no object in their construction. There is no trace of design in

their arrangement, no distinguishable features or relative position. In frequent rides through the prairies, I have looked carefully, but in vain, for a disposition in quincunxes, and called the attention of others to the point, without ever succeeding in detecting it. Neither could I see any marks of labor upon them, beyond the fact that their material was homogeneous. As regards succession or interval in construction, the only possible evidence that can exist is that, in some prairies and parts of prairies, they are larger than elsewhere. As respects the pavement, it bears no evidence of artifice. It is simply the substratum of the whole district, the mass of underlying boulder of the drift.

Farther: the mounds cover so great an area that a population much larger than could have been subsisted in the country would have been required to construct them, unless a great length of time were occupied; and the process would, at least temporarily, have destroyed the only land from which subsistence could be derived. Now, it would be contrary to all experience of Indian character to persist for generations in heaping up these piles unless for purposes of burial, which they clearly are not; defence they never could have been applied to. Again, they seem to be confined to the gravelly and stony prairies, and those where sand or light soil prevails are generally, if not entirely, free from them. If they had been the work of Indians, the easiest ground would naturally have been selected. Among other speculations, one is that they are the product of denudation, or rather that the mounds themselves have been protected by vegetation, such as fern, bushes, etc., while the intervals have been washed away. I examined particularly whether there was any arrangement in reference to drainage, but found that there were no continuous lines, nor any such slopes as would admit of this explanation. Only in one or two swales did the mounds seem to me parallel to the general course. Usually they are as numerous in these

hollows as on higher ground. As to the protection afforded by bushes, it is very certain that clumps of the scrub oak do surmount small hillocks on the skirts of the wood ; but, on the other hand, the mounds proper are too large and too equidistant to admit of this explanation.

Again, they have been attributed to the pushing up of the soil by the roots of the wild cucumber vine (Megarrhiza Oregona), which frequently reach the size of a half barrel, and are very commonly found in them, or that these have at least formed a nucleus about which the soil has collected. But, independent of the fact that these roots are only occasionally thus found, and that they as often grow in level ground, it is much more probable that the vine has here obtained the soil requisite for its growth. That they are not the remains of a burned or overturned forest is clear from comparison with the ground beneath existing woods, where large trees have been overthrown. The piles of earth and rock upturned with the roots always, of course, leave a corresponding depression.

There is again no indication that they are the work of burrowing animals. They exhibit no depressions where holes can have existed, nor, as before remarked, do they contain bones, or evidences of occupation. Instead of being thrown up from within, the mounds have been clearly piled up from without.

Finally, it has been surmised that they are thrown up by springs, at the bottom of the lakes. To this, the same objections of regularity of size and uniformity of distance may be offered, while there are still greater ones, in the equal distribution of gravel through the mass, and the light and open quality of the soil.

To Mr. Agassiz is due the only explanation consistent with all the facts. On exhibiting to him the drawings and description of the mounds, he unhesitatingly declared them to be the work of fish of the sucker family, accumulated in successive years during the lake period, for

the protection of their eggs. A similar process, he states, is going on in Jamaica pond and other little lakes around Boston, and that on a scale which causes no wonder at the size of those of Washington Territory.

In accepting his views, I have thought that their full force could but be given by presenting the facts relating to the mounds, and the various speculations and objections that have occurred to myself and others, notwithstanding their prolixity. As to the era of their formation, it must be of a date geologically modern. It was long subsequent to the deposit of the drift, because a large amount of organic (vegetable) matter has entered into the soil of which they in part consist.

DRIFT OF PUGET SOUND.

The basin of Puget Sound consists, as already described, of slightly-rolling table land, intersected in various directions by deep canals and bays. The whole of this plateau country, extending on the eastern shore from the gravelly prairies of the Chihalis to Burrard Inlet, in about lat. 49° 20′, taking in the peninsula between Admiralty Inlet and Hood's Canal, Whidbey Island, and a strip bordering the southern shore of the Strait of Fuca as far as Observatory Point, is one vast mass of modified drift, almost unbroken by the occurrence of rock in place. From this, however, is to be excepted the group of islands lying between the Strait of Haro and Bellingham Bay, which will be hereafter described. The height of the deposit above the sea level exceeds 300 feet, and, judging from the character of the bottom in the included canals, its depth below that point is in places still greater. Burrard inlet forms the dividing line between the drift and the mountain country which, beyond it, comes down to the water. It will therefore be noted that the inlets of Puget Sound differ from those north of Burrard in this, that the former are excavations in the deposited drift, while the latter are proper fiords.

The general constituents of this drift formation are sand, or rolled stone, and gravel of different sizes, mixed with sand and interstratified with beds of clay; the latter usually occupying a low position in the exposed cliffs. There is some variety in the lithological character of the pebbles in different parts of the sound, trachyte and volcanic tuff or grit being more abundant in the drift at the upper or southern end than lower down, and sandstone predominating both on the Strait of Fuca and in Bellingham Bay—facts consistent with the idea of neighboring derivation. For the rest, a great variety of plutonic and metamorphic rocks, identical with those of the Northern Cascade range, the Olympic group and Vancouver's Island, form the mass of detritus. It is observable that micaceous rocks are almost wanting, and that soda takes the place of potash feldspars. The stratification is sometimes quite distinct, and for the most part horizontal. The sections presented by the bluffs indicate that the unevenness of surface is generally due, not to subsidence or upheaval, but to partial denudation, the lines running out where the ground slopes away. These lines are, it is true, not always continuous, but, after extending some distance, often rise or drop suddenly a few yards, and again resume their former altitude. A very good instance of this may be seen on the western shore of Whidbey Island, opposite Port Townshend. The horizontality is, of course, not universal. In some parts of the sound local subsidences have taken place, which cause a sag, creating an intermediate valley. In others, fractured strata are observable, arising from the same cause. The bluffs are almost always abraded on their water-faces, either by the undermining of waves, or by the wash of rains, which often bring down slides of earth and trees, and their steepness depends in great measure upon the adherence of their constituents. On the inside of Protection Island, however, and near Point Partridge, on Whidbey Island, as also at several points farther up the

sound, faces occur with regular slopes, and covered with vegetation, which have not been destroyed by recent modification. The prairie country around Steilacoom, or between the Nisqually and Puyallup rivers, forms a series of levels, rising in well-marked terraces, which not only border the intervals of water-courses running toward the sound, but face the sound itself. Similar terraces are observable at other points, as near Port Townshend.

I have observed no mollusks in the drift above the sea-level, but beds of infusorial earths occur in various places. These were submitted to the examination of Mr. Edwards, whose report upon them is appended. Very unexpectedly, they prove to be of fresh-water origin; the late Professor Bailey having arrived at the general conclusion, from the specimens examined by him, that all those deposits from the country west of the Sierra Nevada and Cascade range would prove to be of marine, as those from the east are of fresh-water, origin. So far as California is concerned, this seems yet to be true; but the earths from Puget Sound appear, on the contrary, to be fresh-water also. Some specimens from Simiahmoo Bay, on the forty-ninth parallel, which are of more recent character, may be supposed to be the deposit of the creek at that place; but others from Port Ludlow and Colseed Bay, and from the banks of the Skookum Chuck, are properly fossil. As I obtained these from other persons, and did not see them in place, I am unable to assign their geological position. The clays, interstratified with the drift, according to Mr. Edwards, do not contain infusoria. In this connection it may be noticed that most, if not all, of the streams which head in the volcanic peaks of the Cascade range are ladened in their freshets with earthy matter, and that these deposits may possibly consist of vapillæ, which it is known are frequently infusorial.

Below the sea-level the borings of two Artesian-wells at Port Gamble afford a means of determining the char-

acter of the deposits to a depth of 230 feet. A section with specimens was furnished me by Mr. Henry C. Wilson, of Toekalet, as follows:

1st.	Quicksand	65 feet.
2d.	Small boulders	10 "
3d.	Cement of gravel, sand, iron, and clay	20 "
4th.	Blue clay	25 "
5th.	Quicksand containing water and gas	10 "
6th.	Blue clay	100 "

In the last stratum, as in those above, were found pieces of decayed wood and shells. Unfortunately, the specimen sent did not exhibit any of them. The gas is said to be carburetted hydrogen, and to burn with a white light.

Elephantine remains have been discovered in the swampy land overlying the drift. Near Port Townshend two large fragments of tusks were ploughed up; and Dr. Kennerly, of the Survey, obtained another fragment from New Dungeness. Dr. J. G. Cooper also obtained pieces of teeth near Penn's Cove on Whidbey Island. Thin seams of lignite occur in various places, as along the eastern side of Whidbey Island, and at what is commonly called Volcano Point, on Admiralty Inlet. At this place, a seam about twenty feet from the top of the bluff has for many years been on fire, spontaneous combustion having probably taken place from decomposing pyrites, as it is most active during the rainy season.

No general order can be given of the stratification of the bluffs, which varies everywhere; but the following will serve as examples:

Strait of Fuca, near New Dungeness.

4.	Sand and gravel, in beds covered with slides, say	100	feet
3.	Stratified blue clay	3½	"
2.	Brownish clay, impure, with some oxide of iron	3	"
1.	Gravel and sand, coarse	3	"
	Beach of rolled pebbles.		

Point Wilson, Strait of Fuca.

5. Sand and gravel stratified, but chiefly compact sand, say	100	feet.
4. Vegetable matter	2	"
3. Sand	6	"
2. Vegetable matter	2	"
1. Blue clay, containing vegetable traces and imbedded fragments of wood	4	"
Beach of rolled pebbles.		

This section extends for some hundred yards along the shore. The vegetable matter is in a highly compressed bed, running nearly horizontally, of very even thickness, and in almost every stage of carbonization. The upper seam is less regular, thinning out to the westward to four inches. The wood is apparently spruce. One stump, found imbedded in the sand, was about six inches thick and four feet long. It seemed somewhat compressed, but the wood was nearly unchanged. In this seam was found a blue earth, identified by the analysis of Dr. Wolcott Gibbs as phosphate of peroxide of iron, which occurred in small masses imbedded in the sand, and also with the wood. It was noticed only at this locality. At Point Roberts the bluff on the inside, or bay, is, by estimate, about 200 feet high. It consists chiefly of sand, stratified with small gravel, and colored in places with iron. Interstratified with this are seams, a foot or so in thickness, of fine clay. Where intermixed with sand, the latter sometimes segregates itself, showing a disposition to concrete in rounded masses. According to my observation, boulders of large size are seldom seen imbedded in the bluff, although very common at its foot, and sparsely distributed over the surface of the country, indicating a transportation more recent than the deposit of the general mass of drift. Sienite is the most common material of these blocks. Pudding-stone and a hard gray quartzite occur, though less frequently. Some

of the boulders on the beach between Seguina Bay and Port Townshend were from twelve to fifteen feet in length, and one in the woods between Fort Steilacoom and the Puyallup is of still greater dimensions.

As might be expected from the general prevalence of these gravelly deposits, the Puget Sound district presents but a limited amount of arable land. The strictly alluvial tracts are, however, of great fertility, and the roots and smaller grains are of fine quality and very productive.

Tertiary of Puget Sound.

The tertiary rocks of Puget Sound have not been merely tilted by the elevation of the Coast range, but greatly dislocated on the side of the Cascades by local eruptions. It would seem, likewise, that a general subsidence has taken place in this basin, and in the Gulf of Georgia, as it is very unlikely that so extensive a depression should be due to erosion alone, where protected from the encroachment of the sea by an exterior wall. In fact, that local oscillations have occurred in the northern coast, not extending to Oregon and California, is highly probable. The gap in the outer line of islands, between Vancouver's and the Queen Charlotte group, and that known as Dixon's entrance, independent of the chasm between those islands and the mainland, can hardly be ascribed to any less powerful causes.

Outcrops of tertiary rocks occur along the edges of the drift on either side of the basin, but rarely protrude through it. The coal or lignite in which they abound appears also in various places; as on the Skokomish River, a stream emptying into Hood's Canal; on the Nooskope, a branch of the Dwamish or White River; on the outlet of Dwamish Lake; upon Bainbridge Island, opposite the village of Seattle, and on the Stolukwhamish. The only place where any working has been carried on is at Bellingham Bay, and it is there that the

tertiary rocks are most extensively exposed. No lime stone has been observed among them, and none of the calcareo-argillaceous concretions common at Astoria and other southern tertiary localities. The sandstones and conglomerate, or rather grit, line the eastern shore of the bay for some eight or ten miles, extending back eastward to Whatcom and Samish lakes. The trend of the bay is north and south; the apparent strike of the rock about east and west; and the dip, where any is visible, is to the north, at various and generally very great angles. It is, therefore, evident that foldings and dislocations have taken place here to an extraordinary extent. The measurements made by Lieut. Trowbridge, United States Engineers, published by Prof. W. P. Blake in the fifth volume P. R. R. Reports, comprised but a small portion of the entire shore, and even in that distance exhibited unmistakable foldings. He found, in a section of only 2,000 feet, seams of coal amounting to 110 feet in aggregate thickness. It is true that in this portion the greatest number of beds occur, but others are found some miles below, having the same direction, and it is probable that even here they are duplicated. The examination that I made of the shore line was a very superficial one, conducted chiefly in a canoe, and the results are far less satisfactory than could be wished; but the confusion of these rocks is such that a much more careful study might fail to disentangle it.

Three seams were opened some years ago; but, owing to various discouragements, among others the great importation of foreign coal into San Francisco, two of them were abandoned, and the other has but lately been worked to advantage. This is the mine of the "Bellingham Bay Coal Co." at Sehome, about half a mile below the village of Whatcom. The width of the seam here is fifteen or sixteen feet, the dip northward is 42°. The first drift carried in was horizontal, on a level about twenty feet above high-water mark. This was abandoned, and a shaft

sunk fifty feet below it, with an inclined plane, from which other drifts have been worked. The coal seems to be somewhat displaced, rising and falling, but without actual fault, and the bed has been traced back two miles to Whatcom Creek. The cover of the mine is a soft greenish sandstone or arenaceous rock, very similar to that imbedding some of the fossils at Nanaimo. The engineer in charge stated that there were five layers of coal separated by thin seams of fine clay, and differing somewhat in quality. Like all the lignites of the Pacific, it is bituminous. Dr. Newberry's analysis gives for its constituents, fixed carbon 47.63, bitumen 50.22. It exhibits a very clear fracture, and bright appearance when recently excavated, but does not bear exposure to the weather, like the older coals. It has been largely used on the sound by steamers, and considerable quantities have been shipped to San Francisco for the same purpose; but is, as may be supposed, very inferior to true coal, as it consumes with greater rapidity, and gives less actual heat, while the amount of ash is in excess.

Mr. Fitzhugh, the agent of the mine, informed me that at the outcrop he found cones and leaves of firs (probably taxodium) in the shale, but no other fossils. Some 400 feet down the slope, a slab of coal was taken out, some three or four feet square, having a distinct branch of fir with twigs and cones upon it; but it was, unfortunately, broken up by the miners. A very fine specimen of fossil resin or amber, forming a seam in the coal, is among the collections of the Survey.

Immediately in front of the mine, upon the beach, between high-water and low-water marks, are the upturned edges of a stratified sandstone, entirely unconformable to the rocks of the bank, as it dips westward under the bay at a moderate angle, and has a strike north and south It is noticeable in connection with the occurrence of a similar rock having the same strike, but with a much greater dip, in the small cove within Bellingham

Bay, known as Tchukanuts, some miles below, and cut off from the above by a projecting point of conglomerate. It then extends for about a quarter of a mile along the shore, dipping into the water at an angle of 60°. The first bench rises about 100 feet; thence the rock falls back for perhaps sixty yards, and again rises in another pitch.

The total height of the hill cannot be less than 800 feet. This sandstone, which is entirely different from the ordinary sand rock of Bellingham Bay in its perfect lamination, separates in layers of from six inches to two feet thick, with even faces, intersected by diagonal joints. Where the stone has not been weathered, it is of a bluish hue; where exposed to the atmosphere, it takes a drab color, and shows a disposition to concrete in rounded masses.

Whether this is, as the miners suppose, a continuation of the ledge opposite the coal-mine, I had no opportunity to ascertain. The rock has been used in the construction of the light-house at New Dungeness, and also for flagging at Fort Bellingham, and is by far the best building-stone upon the sound. The laminæ of the sandstone, on being detached, exhibit in a remarkable degree the penetrating power of vegetation, a network of fine root-fibres from the trees and bushes overhead having forced itself for many feet in depth between them. The fossil plants from Bellingham Bay have been described by Dr. Newberry in a separate report. They were obtained from two different localities by Dr. R. O. Craig, United States Army, and Mr. Roeder, of Whatcom. They confirm the opinion already entertained, that the age of these deposits corresponds with that of the lower miocene of Europe.

STRAIT OF FUCA.

The shores of the Strait of Fuca, on either side, present as unbroken a line as that of the coast southward, and

it would appear that a gap originally existed at this point in the upheaval of the coast-mountains, tertiary rocks, and the drift which usually overlies them being found on both sides of the strait, indicating that its erosion has been through those deposits only. On the southern shore the drift covers the tertiary as far as Observatory Point; and the bays of Port Townshend, Port Discovery, and Sequim are excavated in this material. Westward of this the conglomerates and sandstones are exposed, generally much disturbed, and in places broken through by trap, which is conspicuous in the headlands, having resisted the action of the water more successfully than the others. Of the conglomerate, numerous small islands and columns line the shore, and at Cape Flattery are conspicuous in detached needles, from 20 to 100 feet in height. I am indebted to the late superintendent of light-houses on the sound, for specimens and data respecting this neighborhood.

About half-way between Pillar Point and Clallam Bay, on the south side of the strait, a seam of coal has been opened directly in the face of the bluff, and a few feet above tide-water. The dip is to south-west about 40°, the strait running east and west. The thickness is but about four feet. There are others above it, but none more considerable. The coal, when first mined, has a clean appearance and a cleavage somewhat like the cannel, but speedily disintegrates with an efflorescence of copperas. It burns with a vivid flame, but, on experiment, proved of little or no value. The seam is underlaid by conglomerate and a greenish shale containing mollusca. The specimens obtained unfortunately crumbled to pieces, but there is little doubt that they belonged to the miocene. A specimen of hard gray sandstone containing a species of mactra was found loose on the shore of the strait near Port Discovery. Mr. Meek, to whom it was submitted for examination, is doubtful whether to consider it as cretaceous or tertiary,

though inclining to the opinion that it is of the latter age, in which belief the locality sustains him.

Archipelago of Haro.

The group of islands lying between the Canal de Haro and the mainland, including Fidalgo and Lummi Islands, consists almost entirely of erupted rocks, trap, and serpentine, bearing upon their sides altered slates and conglomerates. As in the case of the coast mountains, they have been thrust up through sedimentary strata, and remains of sandstone are yet visible, unaltered, though greatly dislocated, on their northern shores. Thus, the northern end of Lummi Island, the portion of Orcas which includes Point Thompson and Point Doughty, the whole of Waldron Island, and the small islands in the Canal de Haro are of sandstone and conglomerate, while the rest of Lummi and Orcas, and all the others, are of erupted or metamorphic rocks; a line drawn from a little above Point Francis, about W. S. W., to the Sannitch peninsula being that of separation Whether these sandstones belong to the tertiary, like those of Bellingham Bay, or to the cretaceous, like those of Nanaimo, and form the southern limit of that basin, no absolute conclusion was arrived at, the fossils collected being chiefly new; but Dr. Newberry, to whom they had been submitted, was inclined to the latter opinion, the more especially as the small islands known as the Lucia Group, a little to the north of Orcas Island, are undoubtedly cretaceous. It is noticeable that along the shores of these islands, slates, which in other parts of this district are rare, occur in abundance. They are greatly altered and contorted, and, in places, beds of several yards in thickness are included in the ejected rocks. These slates, I presume, are of older formation than the tertiary, and perhaps belong to the carboniferous era. Of the same age is, I suspect, the metamorphic limestone of San Juan Island, and that of Esquimalt, on Vancouver's Island. It

is well known that carboniferous rocks exist in the Sierra Nevada, and, although they have not yet been detected in the Cascades south of the forty-ninth parallel, there is reason to believe that the limestones and slates of the Chiloweynck, hereafter noticed, are of this age. Limestone is said to abound to the northward, on Malaspina Island, in the Gulf of Georgia, but of what character I have no information. The limestone of San Juan Island occurs in great abundance on its western side. It varies considerably in structure, from compact to crystalline, and is associated with an altered slate. In point of economical value it is of the highest importance, as no other locality of this material exists in this part of the territories of the United States. All the lime heretofore used on the Sound has been imported from San Francisco or Vancouver's Island. Dr. Kennerly, who visited the quarry, observed boulders which had been dug up from beneath the surface, planed and grooved as if by glacial action.

The only locality among these islands, excepting Lucia, at which fossils were obtained, was on the western side of Orcas, between Point Doughty and the Sannitch fishery. The rocks here consist of sandstones and conglomerates, with interstratified beds of shale, and have a dip to S. E., varying from 35° to 50°. The shales are of very considerable thickness, one bed being sixteen paces across. Vegetable impressions are numerous, and a few shells were also obtained, as also a fragment of a crustacean. The plants are described by Dr. Newberry, but the shells, unluckily, were lost or destroyed. A bed of coal was observed on the beach, beneath the sand, but, from want of tools, was not explored. It is said to be a very extensive one. Large quantities of petrified wood were also noticed. My visit here was made in a canoe, during a very stormy period of the winter, and was too much hurried to make any thorough examination. The Lucia Islands I was unable to reach, and for the speci-

mens collected from there I am indebted to Mr. P. C. West, of the United States Coast Survey. They consist of baculites, ammonites and inocerami, and were described in the report of Mr. Meek, who refers them to a newer member of the cretaceous than the beds of Nanaimo, or to that of No. 4 of the Nebraska series.

This archipelago, to which so much attention has been directed by the claim set up to it by Great Britain, is of considerable interest apart from its strategic importance. It consists of three principal islands, Orcas, Lopez, and San Juan, and of a number of smaller ones grouped around, and covering the several entrances. Within, the landlocked bays and passages afford sea-room for navies, their only fault being the inconvenient depth of water. Fisheries of the greatest productiveness occur along their shores, where the Indians, with their rude nets, catch an abundance of salmon. As regards agricultural advantages, San Juan is the most valuable, about one-third of its surface being arable land, and another fitted for pasture. Upon Lopez Island there is also a considerable tract suited for settlement. Orcas and some of the smaller ones are mountainous; Mount Constitution, on the former, reaching the height of 2,400 feet, and others, on Cypress, Fidalgo, and Lummi, ranging from 1,200 feet upward. The date of upheaval of these islands seems to have been contemporaneous with that of the coast range, or, at any rate, to have preceded the glacial epoch. Very well marked scratches and grooves are observable on the serpentine rocks at the south-eastern end of San Juan Island, apparently running from N. E. to S. W., and it may well have been that the interior basin was, during that period of elevation, filled with a mass of ice.

The terrace formation, which is of a later date, is not so remarkable among the islands as on the main. There are, however, two or three very well characterized terraced hills, one of which, on the inner shore of San Juan,

called Park Hill, is about 450 feet high. This is of sand and gravel, not cohesive, and a large part of the face has been excavated by water, and slid down. The southern face, which is free from timber, is terraced; but the lines are neither so distinct nor so horizontal as the other. A number of sienitic boulders are scattered over it, and lodged on the bare rocks beneath. It is evident, therefore, that their transportation was subsequent to the drift, and that they were brought from a distance is shown by the fact that no sienite exists on any part of this group. Floating ice, therefore, must have come down from the northward after the subsidence, during which the drift deposited took place. Similar hills front the Strait of Fuca, on the south-east end of the island. The terraces follow their curves in horizontal lines, the benches being narrow and somewhat sloping, the banks inclined about 30°. The easternmost is about 250 feet in height, with three benches or terraces, besides its flattened summit. A swale separates this from another to the west, declining, as well as the hills, most steeply northward, on which side, and its ridge, numerous boulders have also lodged. These, like the blocks on Park Hill, are of light-colored sienite, and some of them of great size. A circular excavation in the swale may have been formed by the grounding of an iceberg.

North-west Coast.

In contrast with the almost unbroken coast of Oregon and Washington Territory, that of British and Russian America, as already observed, is deeply indented with sounds, and complicated arms, or fiords, and the same is true of the western or Pacific shore of Vancouver's Island. Mr. Dana, in his Geology of the United States Exploring Expedition, first pointed out the restriction of this phenomenon to high latitudes, and its occurrence there upon both sides of the North American Continent, in Patagonia and Norway, and very forcibly reasoned that it must have

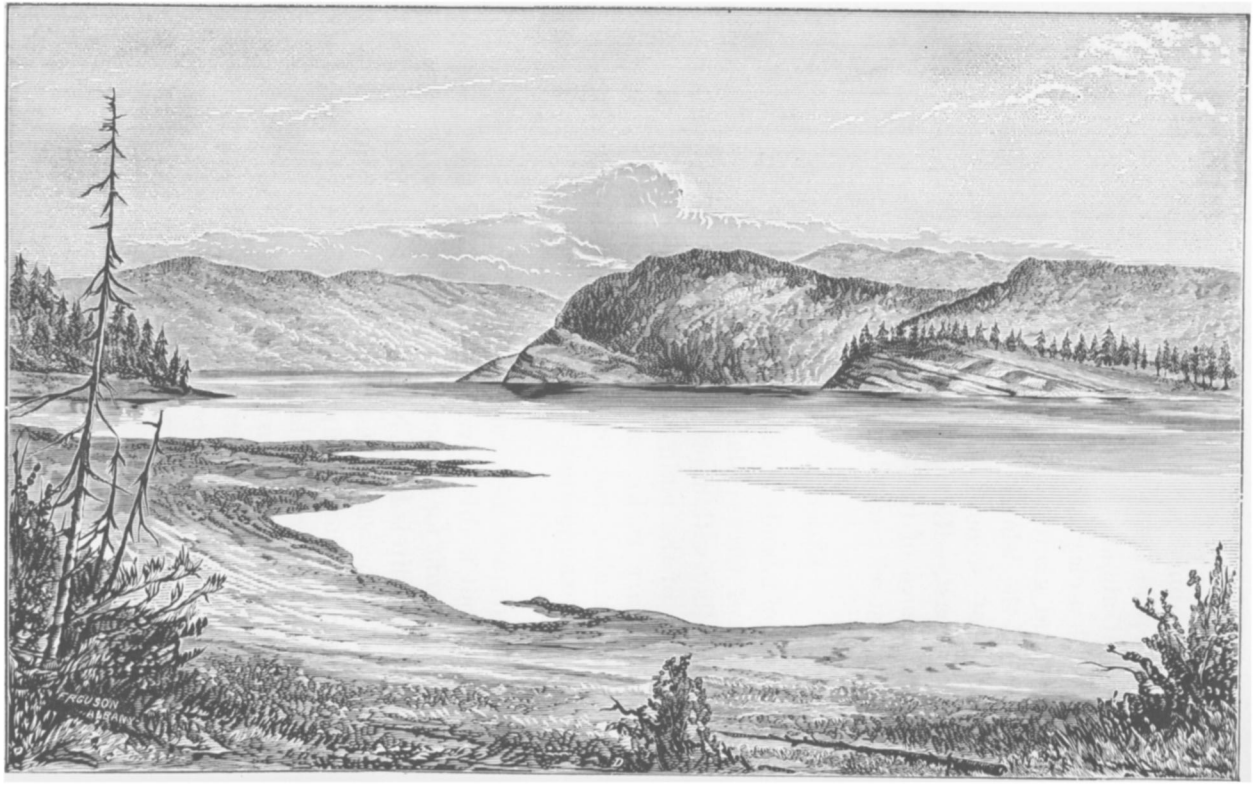
been effected by sub-aërial denudation, at a period when the continent was more elevated than at present, perhaps assisted by glacial action. The probable co-operation of this latter agency is strengthened by the existence of glaciers in some of the northern fiords, where even now they come down to the sea.

Governor Simpson, in his "Overland Journey," speaking of Wrangel's Strait and Prince Frederick's Sound, says: "The valleys were lined with glaciers down to the water's edge, and the pieces that had broken off during the season filled the canals and straits with fields and masses of ice, through which the vessel could scarcely force her way."

The fiords have a remarkable parallelism among themselves, but run diagonally to the course of the mountain-chains, and to those valleys which occupy their interior troughs, pursuing, in fact, the direction which the drainage of the mountains would assume in seeking the ocean. The exemption of the north-eastern coast of Vancouver's Island from these erosions, I presume, arises from the fact that the watershed is nearest it.

VANCOUVER'S ISLAND.

The interior of Vancouver's Island is comparatively little known. It is mountainous, and, besides being deeply indented on the coast-side, abounds in interior lakes. The mountains rise apparently to an equal altitude with those of the Olympic peninsula, of which they are a continuation; and are probably of the same constituents, or with a greater prevalence of granitic rocks. Around Victoria, at the south-eastern end, are sienite, greenstone, and serpentine; and at Esquimalt is also a limestone similar to that of San Juan Island. Among the boulders of Nanaimo River and Mill Creek, sienite, greenstone, and porphyries were common. Many of the rocks in place at Victoria are striated by glacial action, and sienite boulders of large size are scattered over the



VIEW ON ACTIVE PASSAGE, COWITCHIN ARCHIPELAGO.

ground. The grooves were north and south. Gold has been found on the island in small quantities, but so far has not repaid the search.

The soil about Victoria, off the immediate shore, is good, with a clay substratum, but it is confined to small valleys and glades, among the outcrops of rock. This portion of the island, the only part settled in 1859, in character of scenery, more nearly resembles the New England coast,—Rhode Island, for example,—except in the prevalence of timber, than any other section of the Pacific coast with which I am acquainted.

Cowitchin Archipelago.

The line of islands bordering the shore of Vancouver's, north-west of Orcas Island, which may be thus designated, together with a portion of the Sannitch peninsula and a strip of the main island, consists almost entirely of sedimentary rocks, sandstones, and conglomerates, with some shales, and but an occasional dike of trap. A cursory examination was made of these as far as Nanaimo.

The islands are high and broken, almost entirely of rock, with but a thin covering of soil, and the trees are stunted and unfit for timber.

The general dip is to N. N. E., or perpendicular to their trend, the upheaval being from the Vancouver side. Their inner walls are abrupt, and the included channels very deep. As regards the thickness of the formation, no definite conclusion was arrived at. A hill, which I ascended, on Galiano Island, was estimated at 1,000 to 1,200 feet; but if the one on Salt Spring Island is of the same materials throughout, it must reach twice that in elevation above the water. The rock on Galiano Island was a coarse conglomerate of rounded pebbles, underlaid near the water by sandstone. Conglomerates of this description, but varying in the size of the pebbles, are the predominating rock throughout. The sandstone is

generally in thick beds, and the shales, when they occur, are often several yards in thickness. I saw no indications of coal or any fossils.

NANAIMO COAL MINES.

This place is a small bay, on the eastern side of Vancouver's Island, in latitude 49° 10′, longitude 123° 57′ W. It is the place marked Decanso on the old charts, a name given by the Spanish discovers, Galiano and Valdez; that of Nanaimo is the appellation of the Indian tribe inhabiting the vicinity.

It is here that the principal mining operations of the Hudson's Bay Company have been carried on. A considerable amount of coal has been got out, but the works have been conducted with but little system, and in great measure by Indian labor.

The coal lies in two seams; the upper, termed the Douglas seam, four feet six inches in thickness; the lower, called the Newcastle, six feet. Both are accessible, being exposed at different points by the inclination of the strata, and the local destruction of the rocks overlying the latter. The two seams have been worked; the upper at the village, and to the south of it; the lower, on the small island called Newcastle Island, and now, also, in the northern part of the village, where a shaft has been sunk to meet it.

This latter is considered rather the best coal, as well as the most abundant and easily worked. The rocks accompanying both seams are sandstone, and a pebbly conglomerate, with shales, and a soft, green sand-rock, containing fossil remains. The coal is bituminous, makes a great flame, and consumes rapidly, leaving much less ashes than that of Bellingham Bay, and, in place of a friable slag, deposits a black and very adhesive clinker. Although somewhat superior to the tertiary coal, it is yet, owing to its light weight and rapid combustion, estimated, as I am informed by Mr. Davis,

Assistant Engineer, United States Navy, as thirty-three per cent inferior to Welsh coal for steaming purposes. It is, however, used extensively on the neighboring waters, and also exclusively for the production of gas at Portland, Oregon, and at Victoria, in both of which places works have been erected. The gas burns with a very white light, and is more fluid than that produced from the true coals. The amount of gas manufactured from a ton of coal is 8,000 or 9,000 feet.

The limits of this field are not determined. The extent already explored is considerable, and, if properly worked, would furnish a large supply for a large number of years, even if it should not be found to extend beyond the immediate vicinity.

Douglas Seam.

A more detailed section of the rocks overlying the Douglas seam, on the same authority, is as follows: It is that of the Nanaimo mine.

	Feet.	Inches.
Arenaceous, laminated rock of a grayish color, containing a small proportion of argillaceous matter, with occasional irregular seams and nodules of limestone	25	10
Indurated brown shale	25	6
Conglomerate	0	6
Coal	0	6
Shale	11	6
Coal	0	6
Clay	2	6
Coal	0	9
Carboniferous shale	0	6
Coal, principal seam	4	6

Above the Douglas seam, at the present mine, Mr. Robinson states there are five fathoms of conglomerate, where not denuded, as ascertained by boring, over which there are sandstones and shales.

Where already worked, there appears to be of the last not over one fathom; but, nearer the shore, and probably interstratified with conglomerate, fifty fathoms.

There is no shale immediately over the coal. The dip of the bed at the village of Nanaimo is eastward, the angle varying from 25° inland to 45° near the shore; on Newcastle Island it is south and south-east, but these inclinations are apparently local, there being no uniformity for any distance.

The Douglas seam has not been worked at Newcastle Island, though a shaft was sunk to meet it. This was opened near the level of the water, and struck the coal at three fathoms. From appearances it would seem to be covered by sandstones and conglomerates to the thickness of thirty or forty fathoms at the southern end of the island.

On Douglas Island, near Newcastle, a seam somewhat thinner, and of still better quality, is said to have been found, which is supposed to be superior in position to the Douglas coal.

Newcastle Seam.

A shaft has very recently been sunk at the village, where there is a local denudation of the superior strata, striking the Newcastle seam at a depth of fifteen fathoms.

The rock was here chiefly conglomerate, fine and coarse, interstratified with sandstone. Of the latter, the seams were comparatively thin. The coal was four feet six inches in thickness, disposed as follows:

	Feet.	Inches.
Sandstone roof, with partings	2	0
Coal	1	3
Earthy	1	3
Coal	0	6
Shale	0	9
Coal	1	0
Shale	0	3
Coal	1	0

The most extensive work has been done on the western side of Newcastle Island, a drift of about 250 yards in length having been carried in, nearly east, with seven oblique taps, making in all about 1,000 yards. The dip here is south at an angle of 20°.

The northern outcrop of the coal is in a bluff, bordering a sort of valley or ravine, beyond which the island is made up of similar rocks, but greatly disturbed. The following is a section of the bluff, the thickness being estimated:

	Feet.
1. Conglomerate bedded	36
2. Sandstone disposed to concrete in rounded masses	48
3. Sandstone more regularly stratified	12
4. Sandstone compact	4
5. Coal	5
6. Covered with debris, but probably consisting of coarse conglomerate	40
Level of bay.	

It is from this mine that the largest amount of coal has been got out, perhaps 8,000 tons, but it has been abandoned in favor of the shaft at the village.

The principal difference between the rocks here and at the latter place is that the conglomerate is thinner, with fewer pebbles and better stratified

Fossils.

A few vegetable remains have been formed above the Douglas coal at Nanaimo village, which are said to have been similar in character to those below the Newcastle. I obtained two or three specimens, but they crumbled before they could be compared. On Newcastle Island, near the water's edge, and superior to both seams, vegetable impressions and shells, of which a number of specimens were collected, occur in shale; among the latter were Dosinia tennis, *Meek*, Pholadomya subelongata, *Meek*, and a species of Tancredia, the two former being

identical with the specimens obtained on Nanaimo River, in connection with an inoceramus.

The only fossils yet found between the two seams were, it is said, very small marine shells, resembling in form the common cockle, now found in these waters. I was not fortunate enough to obtain any of them.

Some vegetable impressions, including "aspidium Kennerbyi," Newberry, were obtained from the seam of clay, interstratified with the Newcastle coal, in the new shaft at Nanaimo village, the first instance of any being found *in* the coal.

They are numerous below that seam, and, where I examined, consisted for the most part, of ferns and a taxodium.

This place, which is a steep bank bordering the ravine behind the village, presents the following section, the heights being estimated.

	Feet.
1. Conglomerate	30
2. Coal dip 2.25, perhaps the Newcastle seam thinned out	1
3. Conglomerate	15
4. Greenish sand-rock containing plants	4
5. Conglomerate	10

Level of marsh covered at high tide.

On the north side of Mill Creek an opening has been made, near the foot of the high bluff, in a stratum of soft sand-rock, also containing vegetable remains. The impressions resemble those above the Douglas coal, on Newcastle Island. No shells were observed. The shale dips in the direction of the island, about N. E., at an angle of 20°. The relative position of this I could not determine. A salt-spring has been found on the border of this creek, and preparations were making to work it.

Newcastle Island bears marks of a recent elevation in the sandstone on the western side, which has been cut into holes and irregular cavities by water at a height several feet above the present tides, the edges and parti-

tions being very sharp and apparently new. The same excavations were noticed on the inside of Galiano Island.

Nanaimo River.

I ascended this stream for about two miles. The rock, in places where it was visible, along the banks, was sandstone and conglomerate, the prevalent dip being to the east, at various angles; but this direction was not uniform, there being frequent displacement. At the point mentioned, shells were found in the shale upon the right bank, principally Dosinia tennis, *Meek*, Pholadomya subelongata, *Meek*, and an inoceramus not sufficiently perfect to identify.

The river here ran east and west, and the strata dipped into it at an angle of 20°. It was impossible to obtain any satisfactory section, from the fact that the bank was mostly covered.

The bed of this stream is of sandstone, and its depth very irregular, being excavated here and there into deep holes. The rock, when near the surface, exhibited very good examples of the manner in which cavities of irregular and singular shapes are worn by the attrition of two or three stones, their channels running into one another.

From the above facts, it would seem that the entire group of Nanaimo rocks is cretaceous, at least so far as includes all the coal heretofore exposed.

Komooks Fossils.

The locality from which these were derived I do not know, except that it is some distance to the north-west of Nanaimo. They have, I believe, been brought down only by Indians, who find the calcareous nodules, in which they are contained, washed out from clayey banks. The specimens in the collection of the survey were presented by Mr. Robinson, to whom I am also indebted for various others from Nanaimo, and for many of the above facts. The genera obtained from this locality, including

also some in the Smithsonian collection, embrace arca, inoceramus, cardium, dentalium, baculites, helioceras, ammonites (four species, of which one is identical with a Lucia Island ammonite) and nautilus.

BEAVER HARBOR.

At Beaver Harbor, near the eastern extremity of Vancouver's Island, an extensive bed of surface-coal was formerly worked by the Hudson's Bay Company, who thence procured the fuel for their trading steamer. I have seen no fossils from there, and have no information as to its probable age.

The existence of cretaceous rocks on Vancouver's Island was, I believe, first made known by Mr. Meek, in a paper read before the Albany Institute in 1856, and published early in 1857,* based upon specimens received through Dr. Newberry, from the Smithsonian Institution. The collection, as rightly conjectured by Mr. Meek, was derived from two different members of the formation, though both were described as from Nanaimo. I have, however, very little doubt that those contained in the argillo-calcareous concretions were from Komooks, and only those found in the brown or greenish sandstone from the Nanaimo beds. Mr. Meek's first impression was, as appears in the paper referred to, that all were cretaceous, though as to the latter he expressed some hesitation. Subsequently he was inclined to the view that the Nanaimo fossils might be Inrassic, and so stated to Dr. Newberry in a letter quoted by him in his report to Lieut. Williamson. On receiving, in 1858, the specimens forwarded by me, in which the plants of Nanaimo were found associated with inoceramus, goniomya, etc., both these gentlemen agreed in the conclusion that the formation at that locality also was cretaceous. The equivalent to the Komooks beds, to which is now added those of

* Transactions Alb. Inst., vol iv.

Lucia, was recognized by Mr. Meek in 1856, as to be found in No. 4 of the Nebraska series, described by himself and Prof. Hall,* and in other papers by himself and Dr. Hayden, and believed to be synchronous with the white chalk of the Old World.

The Nanaimo sandstone fossils he considers as older in the series. It is noticeable that the plants of this locality are of types believed by many to be no older than the tertiary.

Queen Charlotte Islands.

But few notices of the geology of the northern coast appear in any work to which I have had access. The Queen Charlotte Islands, which are represented on the ordinary charts as a single island, form in reality a group, and, as before stated, are, like Vancouver's, a continuation of the Coast range. Very little is known of them, as the number and ferocity of the inhabitants have hitherto prevented any examination. As early as 1853, attempts were made to pursue the search for gold, which was found to exist there, but they resulted disastrously. It was found in quartz at Mitchell's Harbor, in lat. 52° 25′. Capt. Stuart, of the Hudson's Bay Co.'s service, informed me that specimens of antimony and arsenic, probably arsenical pyrites, were brought by the Indians, it was supposed from Kummeshaw, and that copper was found on the small island off. Pt. Frederick.

The slate from which pipes, dishes, and ornamental articles are made by the natives, is, according to them, found near the canal separating the two largest islands, not far from Skittegets; and specimens of lead ore, black-lead and arsenic were reported as from the same neighborhood.

The north-east end of the group is said to be level and heavily timbered, with marshes and lakes interspersed.

* Trans. Am. Acad. A. and S., vol. v.

Brown coal is found in several places, one on the north end, another on the east side; which renders probable the northerly extension of the tertiary rocks of California and Oregon.

SKAGIT RIVER.

This is the largest stream entering the sound, and the only one, between the Columbia and Frazer River, which cuts through the main range of the Cascades. It has its source in what I have called the Eastern Cascades, near that of the Similkamen, and the small stream entering Frazer River below Fort Hope.

In company with Mr. Grennan, of Utsaladdy, I ascended it in a canoe, at the end of July, 1858, as far as its exit from the cañon, about seventy-five miles above its mouth. The river was then in full freshet, and for a long distance a quarter of a mile wide, very deep and rapid. At its mouth is a delta of low alluvial land, intersected by numerous channels, and for some miles farther the banks are subject to overflow. A little above, where the mouths diverge, commences a series of rafts of drift-timber, three in number, and in the aggregate a mile and a half in length, immovably fixed and utterly stopping the navigation.

But for this obstruction, light-draught steamers could navigate it for a distance of nearly fifty miles. A large body of very rich land lies on the lower part of the river, much of which is, however, heavily timbered. About fifty miles up, a branch enters, having one of its sources in Mt. Baker, and ten miles beyond is the south fork, or Sakumihu, up which is an Indian trail to the Columbia by way of Lake Chelaun. Near the former, called the Hukullum, the river becomes narrowed, the hills setting in and rapids commencing, though there are still long stretches of smooth water.

The cañon of the Skagit, by which it passes through the Cascade range, is by report some eighteen or twenty

EXIT OF THE SKAGIT RIVER FROM THE CANON.

miles in length. Rapids and falls of some height occur in it. The scenery is exceedingly picturesque, the mountains rising directly from the river in abrupt and rugged forms, but covered with forests.

The general range of the mountains bordering the Skagit seemed to be from N. E. to S.W., not running in continuous chains, but attached parallel ridges placed in echelon. On the lower and middle parts of the river they exhibited long sweeping lines, with pretty steep declivities, say from 30° to 40°, and very generally capped with regular cones. Higher up they were more broken, and snow peaks were frequently visible.

One very remarkable mountain, called by the Indians Hugweht, apparently overhangs the water on the right bank, some miles above the Hukullum.

It was apparently of basaltic conglomerate. Mt. Baker is seen from only two or three points, and presents an entirely different form from that seen from the sound, its summit being roof-shaped, instead of pyramidal.

At the time of my visit, reports of the existence of gold on the Skagit, and the hope of finding a route to the Frazer-River mines, had led quite a number of persons to ascend it.

The color of gold was found in one or two places, but no favorable indications.

The height of the water was, however, an obstacle to any thorough prospecting. Bluffs of drift, overlaid with blue clay, occur at intervals along the river, corresponding to those on the sound, and in one of these I noticed, near the level of the water, a seam of ligneous matter, about a foot in thickness, having a slight easterly dip. The bluffs are sometimes 300 or 400 feet in height, and very uneven on the surface, but the general stratification is horizontal, or nearly so, and no great changes have taken place since their deposit.

The first rock in place occurs some twenty-five miles from the mouth, a little above the crowning of the pro-

posed military road to Bellingham Bay. It consists of argillaceous and mica slates, the latter with veins of quartz, very much tilted and often contorted, having a general strike of N. E. and S. W., in conformity with the apparent range of the hills.

In the bed of the Hukullum I obtained specimens of vanon, colored porphyritic trachytes and scoriæ, brought down from Mount Baker, and which may probably form the sharp and ragged spurs which break off from that mountain.

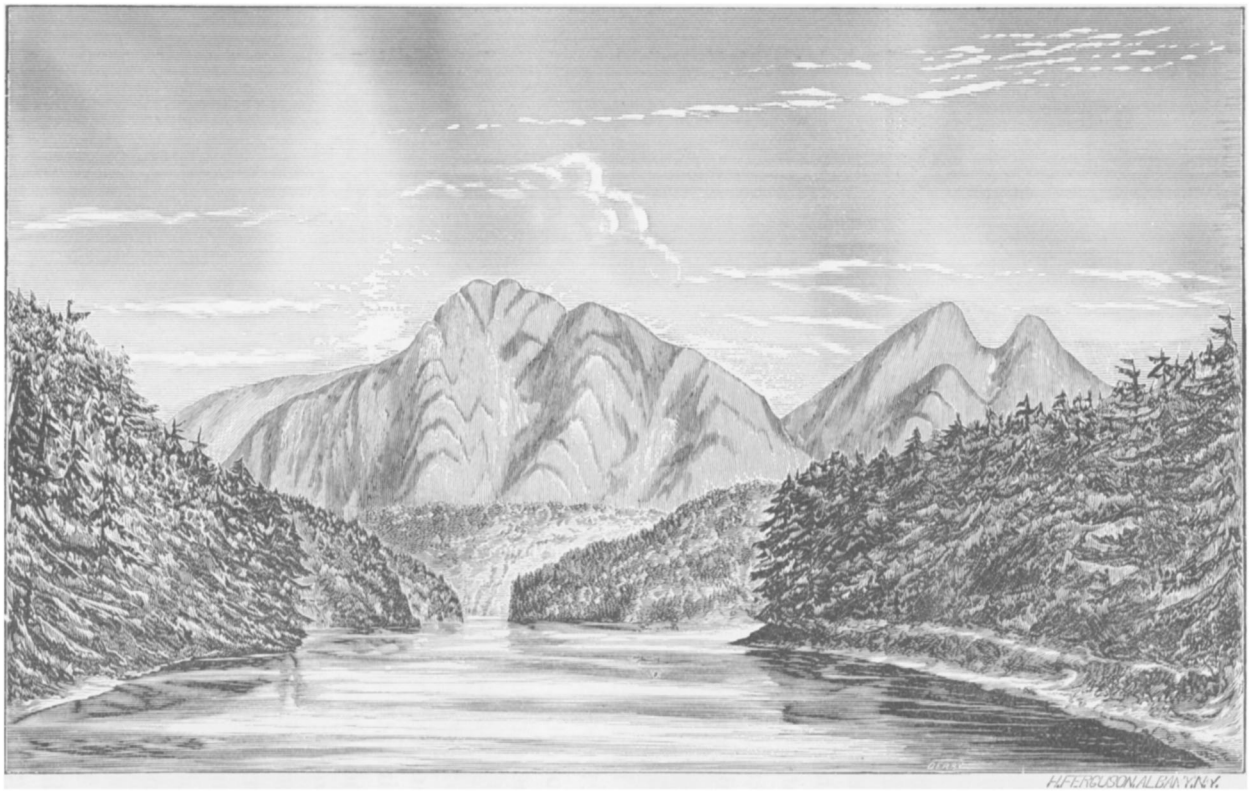
The color of the water here is a dirty white, caused, I presume, by volcanic ashes held in suspension, contrasting with that of the Skagit, which, though itself discolored by the freshet, was of bluish hue.

Some miners, also, had ascended it, for a couple of days, to within a short distance of the snow, described it as passing through a cañon, narrowed at one point to twenty feet. Its heads were in the gorges which score the sides of Mount Baker.

At the foot of the mountain was a level plain two or three miles wide, of black volcanic rock and sand, upon which were vast piles of half-burned timber, apparently swept down by a current of, as they supposed, lava, but more probably water.

A stream of lava was visible on the side of the mountain, and also on this plain, and sulphur was found scattered over its surface. They saw smoke ascending on the eastern side, about two-thirds the distance above the snow line. The Indians living on the river told me of an eruption of Mount Baker, many years since, doubtless the same which Mr. Yale has referred to, as elsewhere mentioned.

I noticed no trachytic boulders above this stream. The slates continued for some distance, when they were succeeded by sienitic quartz ore and felspathic rocks. The boulders consisted of the usual variety of crystalline and porphyritic rocks, serpentine, actinolite, and slates.



VIEW ON FRAZER RIVER—ABOVE FT. HOPE (looking down).

In crossing the mountains, during the subsequent season, I had an opportunity of examining this river, above the cañon. It presents, on a small scale, a very remarkable parallelism to Frazer River. Heading, as before mentioned, east of the true Cascades, in about the latitude of Fort Hope, it pursues, at first, a southerly course in a trough between the two ranges, and, cutting diagonally through the main range, runs westerly to the sound.

Its valley above the east fork, where the passage through the mountains commences, is narrower, not exceeding a mile in width, and consists of level tables or terraces, rising to the mountains on either side. This bottom, which is twenty or twenty-five miles in length, and separated into two basins, is stony, with but little soil, except here and there on the bank, and most of the timber is thin and scrubby.

Frazer River.

Frazer River, which, down to Fort Hope, in longitude 121° 30′ and latitude 49° 27′, somewhat over 100 miles from the coast, pursues a general southerly course, there turns suddenly westward, emptying into the Gulf of Georgia, in about latitude 49° 6′. Its volume of water is nearly as great as that of the main or north fork of the Columbia above Walla Walla. Besides several minor tributaries, it receives, below Fort Hope, two large ones, both entering from the north,—Pitt River, about twenty-five miles from its mouth, and Harrison River, some thirty-five miles further, each being the outlet of a large lake. Pitt Lake is said to be about twelve miles in length; Harrison is about twenty-five or thirty. They both fill deep gorges in the mountains, which rise abruptly from their banks, and in many respects bear a strong resemblance to the fiords of the coast.

The latter is fed by the Silowat, on the upper waters of which is another similar expansion, connecting by a portage, and another chain of lakes, with Frazer River, about

100 miles north of Fort Hope. These two add, of course, a considerable part to the ultimate volume of the main stream.

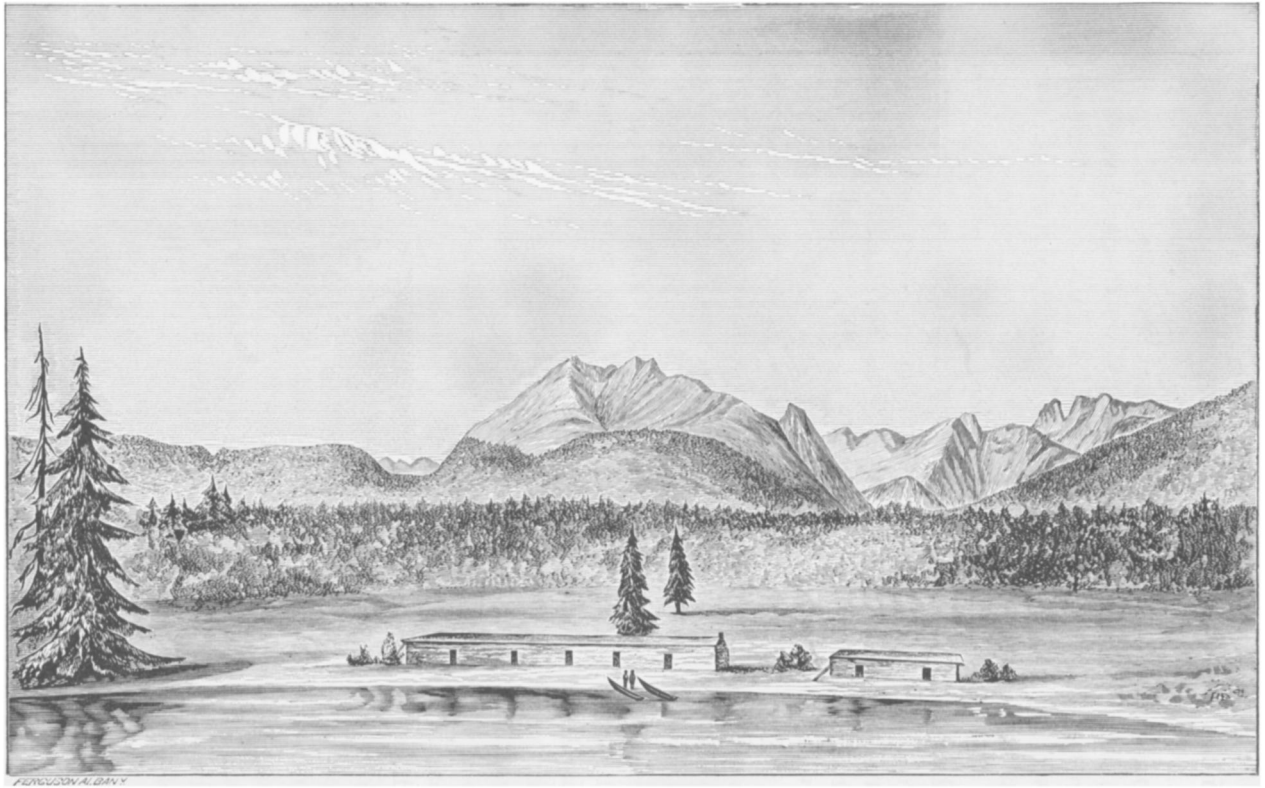
The entrance of Frazer River into the Gulf of Georgia is marked, as might be expected, by shoals, the deposit of its freshets. An extensive tract of alluvial land, for the most part wet and unfit for cultivation, lies between its mouths, and, on the south, reaches to Siniahmoo Bay. Another mouth would seem, indeed, formerly to have entered that bay, leaving Point Roberts as a separate island.

The immediate banks of the river are chiefly alluvial for a distance of fifty or sixty miles, and are overflowed in the summer season. They are covered with cotton-wood and a thick growth of willows. Back from the water are a few small prairies, of which the largest are around Fort Langley, and on the Sumass and Chiloweynck. The low lands much resemble those on the Lower Columbia.

The prairies are rich, having about a foot of black mould, with a subsoil of clay and sand. As they also are, to a great degree, subject to flood, the amount of land fit for cultivation is to be measured rather by acres than miles.

It is here, between Burrard Inlet and the Nook Sahk, and extending from a little above the Chiloweynck to the mouth of Frazer River, that the only level country in British Columbia is to be found.

The river, for a great part of the distance to Fort Hope, spreads out into numerous channels, some of them dry at low water, having extensive "bars" of sand and gravel, and low islands between them. It is often, in fact, two or three miles between the extreme banks. The influence of the tides is felt as far as the Sumass, fifty-five miles up, where the first rapids occur. Thence to Fort Hope the average fall is from sixteen to eighteen feet per mile.



THE LANGLEY BUTTE, FRAZER RIVER.

The valley becomes permanently narrowed at eighty miles, mountains setting in on both sides.

Above Fort Hope the river itself is contracted in its passage through the gorge of the mountains.

Here the rapids become much more frequent and difficult, and near Fort Yale the first falls occur, beyond which, even canoe navigation is highly dangerous, and at times impracticable.

The freshets commence, according to the season, from the middle of April to the beginning of May. The water reaches its height toward the end of June, and remains up until some time in August. As near as I could judge from the water-marks, the rise at Fort Hope must reach twenty-five feet.

Our first visit to this river was in March, 1858, where a canoe party, consisting of Mr. Gardner, Dr. Kennedy, Mr. Peabody, and myself, ascended as far as Fort Yale, fifteen miles above Fort Hope. At this time reports of the discovery of gold upon its banks had just reached the lower country, and we met, on our return, the earliest parties who were proceeding to explore it. The only whites then resident were those belonging to the Hudson's Bay establishment of Fort Langley, and the small post at Fort Hope. We had amused ourselves, as we paddled round the bends of the river and coasted the shores of Harrison Lake, in speculating upon the time when the stroke of the axe, or the dash of wheels, should awaken unknown echoes among the mountains, little suspecting that in a few months steamers would run in opposition-lines upon those waters, that the tongue of half Christendom would be heard there in chorus, and the uncouth utterances of the Indian be rivalled by those of the Chinese.

The country on the Upper Frazer, or that above Fort Yale, was not examined by any of our parties, but from the description of others it is not such as to invite settlement.

On the west side of the river there are high rocky mountains, covered with snow in June.

On the east side, above the great cañon through which it passes the mountains, it consists of table-land 1,000 to 1,500 feet in height, timbered only in the ravines, unfitted for agriculture, but affording good grazing.

The cold in winter is intense, but the amount of snow not very great. Ice does not disappear altogether until April.

Farther north, the winters are represented as almost Arctic in severity and duration.

The whole country between Frazer River and the coast consists of mountain-ranges extending in a direction N. N. W. and S. S. E.

These, where they do not reach into the region of perpetual snow, are, as in the Cascades, covered with forest. They present the aspect of heavy masses, with steep slopes down into narrow valleys, or rather gorges, their crests being often surmounted by sharp and angular but sometimes mamillary points.

The passage of Frazer River through the mountains, though perhaps inferior to that of the Columbia, is still a scene of rugged and desolate grandeur. The forms of many of the summits are singular in the extreme. The forests which hang on their sides are broken by escarpments of rock, and the river, itself compressed within narrow walls, rushes through as if impatient for the liberty of the ocean.

The common rocks throughout these mountains are granitic, sienite being most abundant, true granite, as usual, less so. Diorite and eurite were occasionally noticed. Quartz alone, however, is the constituent of even mountain-masses. Almost all of these contain pyrites, giving them, when exposed, a general sombre hue. Talcose slate occurs on the east side of Harrison Lake, at the peninsula, pudding-stone at a single locality near Fort Hope.

I have elsewhere spoken of Burrard Inlet as constituting the northern boundary of the drift. This formation is not conspicuous on Frazer River, but still shows itself at various points, as in a range of up and crossing it below the mouth of Pitt River, and again at Fort Langley. It occupies much of the country between Frazer River and the Nooksahk. Point Roberts is a detached mass of it. As a general thing, the constituents of the drift here are finer, containing more sand and less gravel than farther up the sound.

I saw nowhere any tertiary rocks, though doubtless they underlie the lower basin of Frazer River. Since the commission left this part of the country, coal has been reported on Burrard Inlet, but whether it belongs to the miocene or cretaceous I have not heard. Its geographical situation would point to the latter. Metamorphic slates were noticed at several points on the river, seemingly resting against the sienite; as, for instance, at the foot of the isolated mountain near the mouth of the Sumass.

The mineralogy of Frazer River, apart from the gold, is uninteresting. Native copper has been found in small quantities, and a silver-mine was reported to have been discovered above Fort Hope; but the specimens furnished me for examination contained nothing but galena. The gold placers have been so largely developed since our visit that I do not venture to describe them.

The history of exploration here, as well as in California and Australia, is one to which new chapters are daily added. The metal found below the cañon was in fine particles, showing the distance of its origin, and was soon exhausted by the swarms of miners who poured in during the earlier excitement.

Amidst many discouragements, the search has been extended up the river to its remotest sources, until, in the extreme north, where the severity and duration of the winters is appalling, and all transportation is on the backs

of the Indians, it has been found in an amount and in such large masses as to recall the palmy days of California and Australia. As usual upon the Pacific coast, platina is found associated with it.

At the lower end of Harrison Lake, near the outlet, a hot spring bubbles up among the rocks, close to the water's edge, emitting a very perceptible odor of sulphur, and having its peculiar taste. Having no thermometer reading over 130° Fahr., we were unable to ascertain the temperature, which much exceeded this, being probably not less than 180°. Some of the water was brought off for analysis, but the bottles containing it were unluckily broken. A qualitative analysis of the deposit, made by Dr. Wolatt Gibbs, gave oxide of calcium, anhydrous sulphuric acid, and a tolerable quantity of binoxide of silica and chloride of sodium, with smaller parts of sesqui-oxide of alumnium, sesqui-oxide of iron and oxide of manganese.

The changes occurring on the bars and low islands of this and other similar rivers present many points of geological interest.

In places a recent deposit of sand or silt, a foot thick, covers the sod or vegetable accumulation of previous years, willow and brushwood protruding through it. Elsewhere trunks of trees are seen in the banks, imbedded to the depth of several feet. Sometimes large piles of driftwood, including immense trees, lodge upon the bars, and the eddies caused by the freshets excavate beneath them deep hollows, into which they settle down.

At the time of our ascent, masses of ice were lying upon these flats, melting in the sun or rain, and leaving deposits of earth and stones, which they had brought with them, as well as deep furrows ploughed up in their progress.

The surface of many of the gravelly bars, in fact, looked like a potato-field after harvest. Ascending the river, the change in the size of the detritus was noticeable.

Above the Sumass, the bars, which had been exclusively of sand, became gravelly; farther up, the gravel was succeeded by pebbles and cobble-stones, and on entering the mountains, near Fort Hope, irregular masses of rock, often of large size, line the banks; some fallen from above, others transported by ice. Immense numbers of the skeletons of salmon, which had drifted down exhausted by spawning, were scattered over the bars, the vertebræ sometimes connected, sometimes broken up, and the bones perhaps lying in piles, where birds had been feeding. Leaves of various trees were also plastered over the stones. On the sand and mud, besides these remains, were footprints of men, dogs, and birds, and cracks produced by drying in the sun. All these were in store for the geology of times to come.

Western Slope of Cascade Range.

The Chiloweynck and Nooksahk, secondary streams, run in transverse troughs between spurs, and do not serve any range. It is noticeable that the upper and middle course of these streams are exactly parallel to each other, and the Skagit, and some of its branches opposite, and likewise nearly parallel, make, as it were, acres of concentric circles around Mount Baker. Another point observable is, that Frazer River, the Nooksahk, and Skagit, as they approach the coast and enter upon the lower table-land or alluvial bottoms, all deflect from their westerly course and turn south-west at nearly the same angle. The cause of this uniformity, for cause there must be, I have failed to detect, unless it be in the tendency of rivers to conform their course toward the point of ultimate *debouchement.*

Thus, the Strait of Fuca being the common outlet of all these waters, and the ebb, aided by the river-current, being stronger than the flood, the mouths of the streams have, where from the nature of the ground they could be affected, varied in that direction. The course of the

Skagit, at a superficial view contradicting this, really corroborates it, as its waters pass round to the south of Whidbey Island. In like manner the Swohomish, and other streams emptying farther up the sound, run toward the north-east.

The mountains nearest the coast appear to have been formed by the intrusion of igneous rocks through the sedimentary strata of the Puget-Sound Basin, slates being prevalent to a height of at least 4,000 or 5,000 feet, or to that of the main divide between the Chiloweynck and the Nooksahk. Mr. Custer found slate and limestone on the summit of Signal Peak and dolomite on that of Layomesan.

Following up the Chiloweynck, limestone and slates are the prevalent rocks.

These are usually much altered and upturned at various angles. I saw no fossils in place, but two fragments of limestone were found in the river, including organic remains; one crinoid, the other a coral, which, in Mr. Meek's opinion, were either Devonian or carboniferous, but they were not sufficiently characteristic to identify them with certainty. I suspect that the latter hypothesis is the true one, and that they here represent the carboniferous rocks of the Sierra Nevada; the crystalline limestones of the Chiloweynck, like those of San Juan, being merely altered forms of this epoch.

On the Nooksahk, near the mouth of the Cowap Creek, Mr. Custer found numerous fragments of slate containing vegetable impressions in a high bank, which Dr. Newberry recognized as tertiary, and similar to those of Bellingham Bay.

The mountains between the Chiloweynck and the Nooksahk were explored by Mr. Custer. The average elevation of the general divide is about 5,000 feet, the peaks reaching 6,000 to 7,000, with a few as high as 8,000 or 9,000 feet.

It is noticeable that the highest are not situated upon

the main divide, but upon spurs. The watershed is nearest to the Nooksahk, and the streams running into it are, of course, short and excessively rapid.

The affluents of the Chiloweynck are themselves torrents, their descent being from four to five feet in a hundred.

The scenery of this region, as might be supposed, is wild and picturesque to a degree. The higher peaks rise in almost acicular points of naked rock, accessible only to the foot of the mountain goat; broad snow-fields, which hardly yield to the last heat of summer, are interspersed on the more level summits, or lie in sheltered basins; precipices of tremendous height overhang the heads of the streams, among which are inclosed small but deep lakes; cascades leap down the sides of the mountains, and spread over the lower ranges is the deep forest of evergreens.

On the south peak of the Tummeakai, just at the line, a fall of forty or fifty feet in height marks the boundary, and others above it make in all some two hundred feet. On the west side, a few miles below, are two cascades falling into it, from the mountain, one of 100 the other of 150 feet.

A still grander scene is at the Putlushgohap Lake, on the eastern fork of the same stream. There the mountain overhangs the water in an almost perpendicular bluff of 1,000 feet; cascades, some of them nearly half that height, fall in spray from its sides; the lake itself, towards the end of June, was still sheeted in ice and snow, and its outlet was a continuous fall of nearly 1,000 feet in half a mile. Above the noise of the stream the roar of avalanches was heard at intervals.

Chiloweynck River and Lake.

The boulders in the lower part of the Chiloweynck were chiefly gneiss, sienite, greenstone, felspathic porphyry and earthy jasper, with a finer gravel of slate. The first granitic rocks noticed, on ascending the river, were on the Senehsai, about half-way between the bend of the river and the lake.

The rock there was on the south side sienite; on the north, quartzite, gneiss, and sienite, with some slates; and upon a high peak, ascended by Mr. Custer, sienite, quartzite, and diorite. Around the lake the mountains are almost entirely sienite, externally blackened by the decomposition of pyrites.

In its feeders, however, were pebbles of argillaceous and felspathic porphyry.

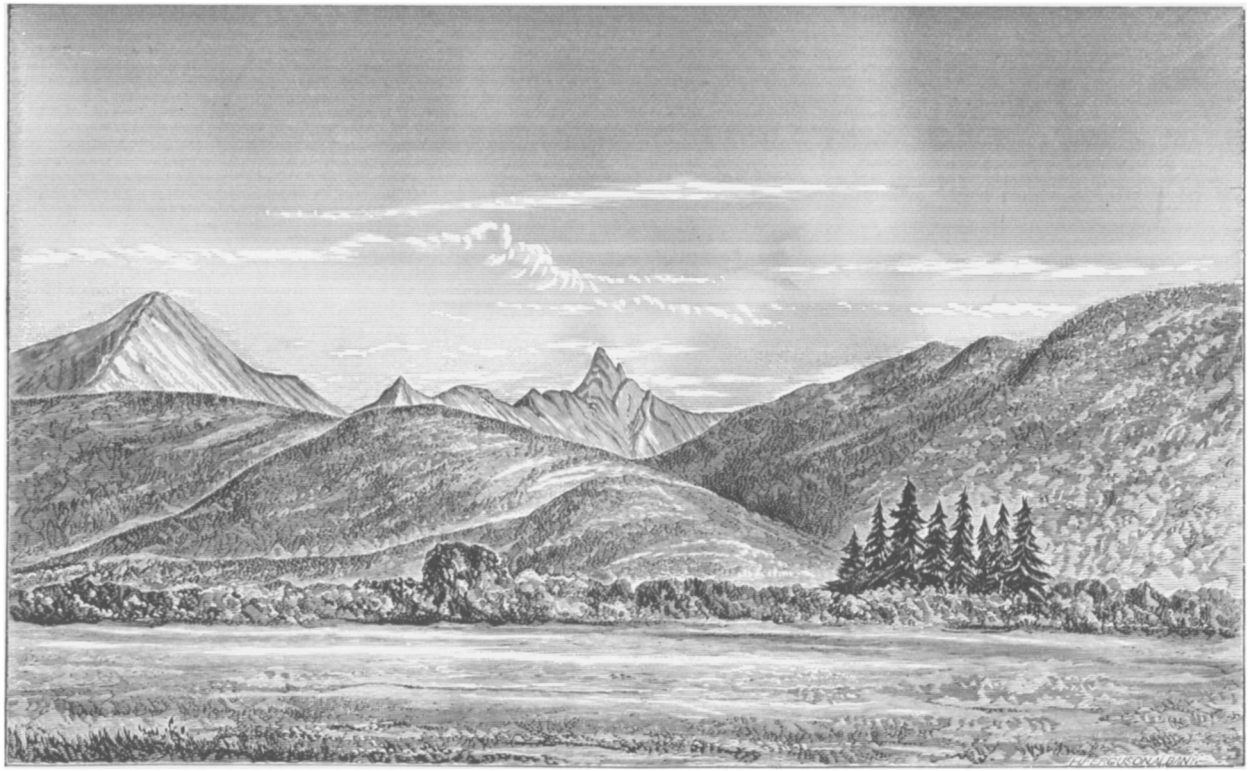
The Chiloweynck constitutes the most favorable access to the parallel through the mountainous region south of Frazer River, one of the tributaries of the lake from which it issues heading in the Chuchchehum Pass, in the immediate neighborhood of the line..

This stream enters Frazer River near the point where the level country ceases, turning suddenly from its westerly course northward round the foot of a range of hills.

At its mouth is a tract of prairie-land, of some extent compared with the rest of this region; but, as usual, it is liable to flood. Above its bend it has no valley, the hills coming down close on either side, and leaving only occasional bars. Throughout, it is a bold and rapid torrent, though without any actual falls, the water running over a bed of boulders with an average descent of about fifty feet to the mile.

Camping on its banks, one hears at night the noise of these stones moving over one another, often resembling the human voice, and can hardly wonder that imaginative races have peopled such streams with spirits and demons.

The lake is about five miles long, and its height above



VIEW ON CASCADE RANGE—FROM CHILOWEYNCK RIVER, NEAR 49th PARALLEL.

the sea over 2,000 feet. It is environed by mountains, the peaks of which reach an elevation of 5,000 or 6,000 feet above its level, and are covered with snow-fields and glaciers. Its waters are very deep, clear, and transparent, and the views it presents are almost unequalled, even in this region of wild and solitary grandeur.

While stationed at the depot, near the upper end of the lake, I carried a line of soundings across to the opposite shore. Its width here was 1,200 yards, and the depth was found to increase gradually for about a third of that distance, where it attained thirty-five fathoms.

This was maintained to within a short distance of the western bank, where forty fathoms were found. Its depth is doubtless much greater farther down the lake, where it is wider and less affected by the detritus of the streams. At either end a beach of coarse white sand, of quartz and felspar, was thrown up, the result of disintegration, as the sienite and small patches of sand, brought down by its two affluents, extend out to some distance. Below the lake, stretching like a dam across the valley, is a high plateau or terrace, cut through on the south side by the outlet.

At Chiloweynck Lake the pass of the Cascade range commences, following up one of its feeders to the summit, a distance on the parallel of about nine miles.

Upon the creek is a small lake, or enlargement of the stream, caused by a slide from the mountain, which has blocked up its course, the sides being steep slopes of rocky débris.

This pond presents an interesting phenomenon in the beautiful color of its water, arising from a deposit on the bottom. In the deeper parts it is a pure azure; where shallow, of a light milky or verdigris blue. The deposit is gelatinous, and covers the entire bottom, clinging to stones and sunken logs, strewed over it, to the depth of a tenth of an inch. When first taken up it was of a milky, opal hue, but becomes gray when dried. The water itself

is perfectly transparent and tasteless, and the deposit has merely a slight earthy taste. It is evidently brought down by the brook. The lake becomes dry in the late summer and fall.

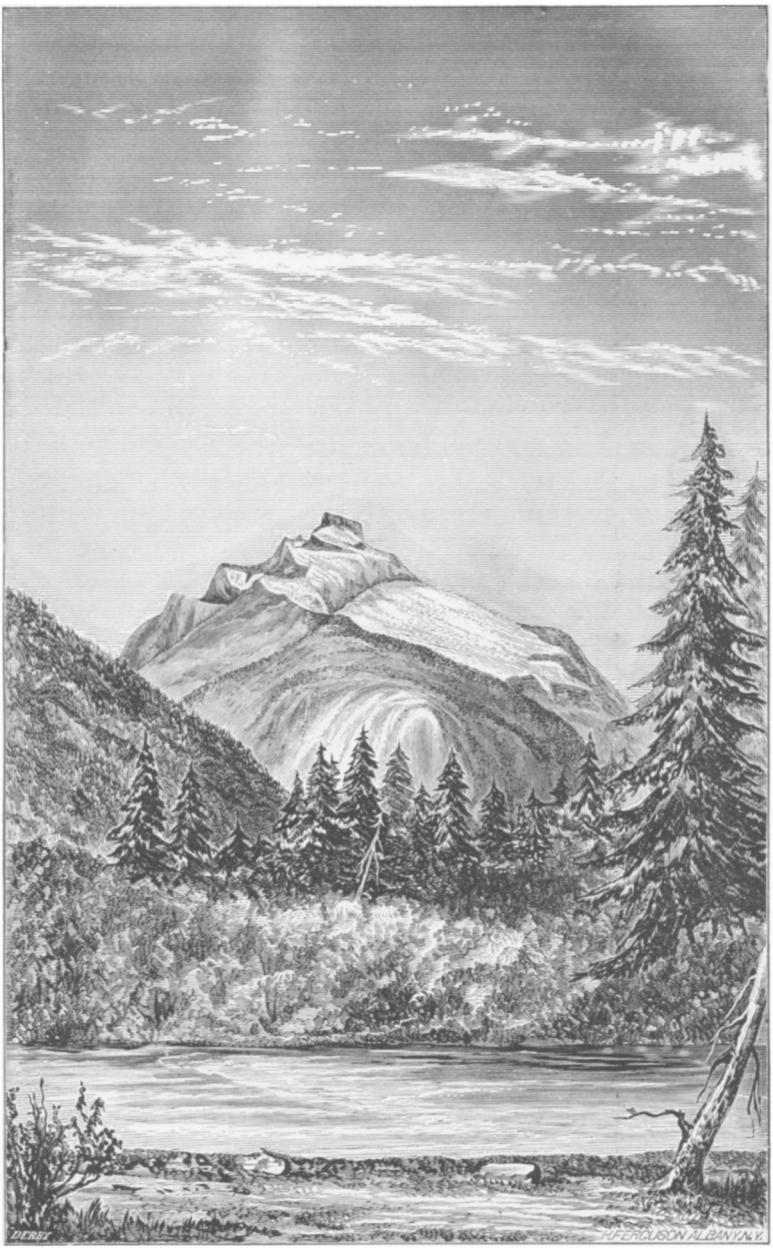
The divide at the head of this pass forms, as it were, a bridge or level plateau, perhaps a quarter of a mile wide, connecting the mountains on either side. I had not time, in crossing, to ascertain its identity with the drift, though, like the terrace at the foot of the Chiloweynck Lake, its conformation suggests such an origin.

The height of this divide is 4,533 feet above the sea. A corresponding ravine, one of the sources of the Manselpannik, a stream emptying into the Skagit, heads under it on the east. The pass, therefore, though on the summit of the true Cascade range, is not a watershed between Frazer River and the Columbia, but only between two streams debouching through the Strait of Fuca.

A noticeable feature of nearly all these mountain streams is that, on their upper waters or directly under their principal sources, they run through narrow but *flat* valleys, having a comparatively gentle slope, once undoubtedly the bed of what may be called fluviatile lakes or expansions of the rivers, and that their lower or middle course, according to the length of the stream, is more rapid and broken.

Thus Mr. Custer found, on the Upper Nooksahk, a level bottom of some fifteen miles in length and a mile wide, heading in marshy lakes, below which the river resumed the character of a mountain-torrent, until it reached the drift and alluvial lands of the sound.

The elevation of this valley is about 2,000 feet above the sea. On the Chiloweynck, the principal feeder of the lake, called by the Indians Klahaihu, in like manner carries a level valley to almost its very source. The same is true of the Upper Skagit, and, in fact, of nearly every stream of considerable length, and measurably so of the great branches of the Columbia itself.



MOUNTAIN ON KLAHAIHU CREEK.

The larger rivers frequently present a series of these basins. It is not only through districts easily eroded that the lower rapids occur, but frequently among rocky hills through which they have excavated cañons.

I have used the phrase *flat* valleys to designate those which present no visible concavity in their sections, but where deposits have created a level surface between the inclosing mountains. The occurrence of this form, as distinguished from the shape assumed in erosion, is exceedingly common.

Cascade Mountains. (General Features.)

The geological features of the Cascade range, north of the Columbia River, so far as exhibited on their eastern declivity, were described at length in a previous report.* From Mount Rainier, the rocks observed were chiefly trachytic or basaltic, with eruptions of lava of various ages, some of those of Mount St. Helen's being of very modern date. Interstratified with the basalt is a volcanic conglomerate, generally of a reddish color and very harsh texture, containing often masses of basalt and lava, but at other times assuming a tufaceous character.

North of Mount Rainier, crystalline and metamorphic were mingled with volcanic rocks in the boulders of the streams, until reaching the Winatsha, when the two former alone prevailed. I have since had an opportunity of crossing the mountains by the Nahchess Pass to the north of Mount Rainier. The rock, in places, from Mount La Tête to the summit, and thence some distance down the eastern side to Edgen's Rock, was volcanic conglomerate, and this, judging from appearances, constitutes the elevated points from Mount Rainier northward.

That portion of the chain exhibits a very marked difference in profile from the more southern, ragged and

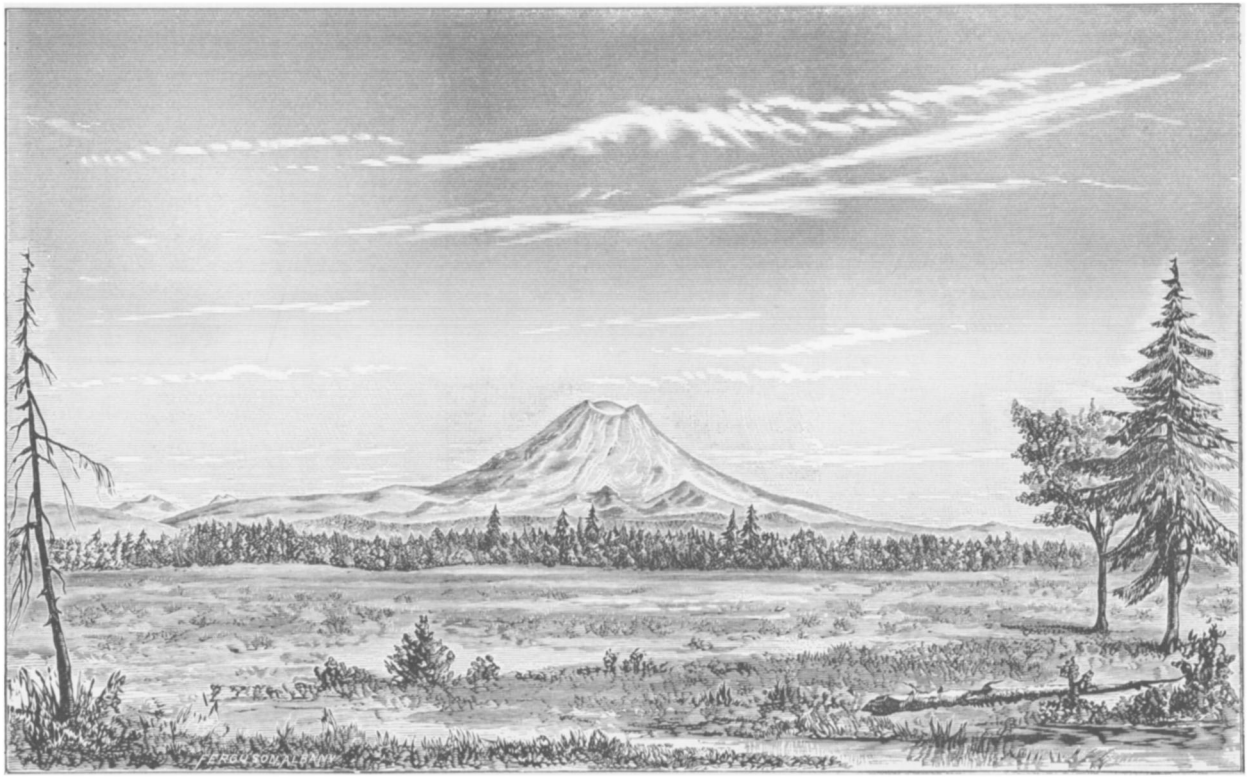
* Vol. i, P. R. R. Reports.

broken peaks replacing the flowing lines and broad surfaces of the latter.

In ascending the Chuchchehum Pass, from the west, the rocks noticed were a fine-grained lamellar feldspar, quartzite, and diorite. On the mountain, to the north, sienite, quartzite, and slates, the former most prevalent; and in descending, to the eastern side, gneiss and slates, and a dark-colored quartz rock. On the mountain, south of the pass, I observed chiefly slates, with seams of quartz, greatly inclined and sometimes vertical. Still farther south, Mr. Custer, who took a route up the Klahaihu, crossing the range and descending to the Skagit valley by a branch which he named Glacier Creek, found sienite and a rock consisting of quartz and felspar without hornblende. The sienite appears to form the highest peaks of the range. In the Skagit valley, sienite, diorite, and quartz predominated. The summits of this portion of the range rise into sharp and serrated ridges, or peaks, of which a characteristic feature is, that on all the highest, nearly perpendicular walls, either of sienite or slates, inclose sloping basins, conveying the idea of craters, one side of which has broken down. These are generally the seat of snow-fields, or glaciers. Mr. Custer's observations, which were very extensive, led him to the conclusion that most, if not all, of them faced to the west or north, the greater number to the west.

LINE OF PERPETUAL SNOW.

As is everywhere the case in temperate zones, the altitude of the line of perpetual snow is too variable to be stated with certainty. On the northern sides of the mountains, in deep and sheltered gorges, and the crater-like basins, snow often lies all the year round, at points comparatively low down, while the summits themselves are bare. The sharp and precipitous crests of the higher peaks are unfavorable to the retention of snow, which slides in avalanches into the gorges beneath.



MT. RAINIER—FROM FT. STEILACOOM.

Of the true snow-peaks, the isolated volcanoes which rise far above the general range, Mount Baker, 10,800 feet high, and Mount St. Helen's, probably 12,000, are sometimes almost entirely denuded of snow, while even on Hood and Rainier it disappears to a great extent. On these, much of the melting is indeed probably due not to the heat of the sun, but to the warmth of the rocks beneath, under which the fires are not yet extinct.

The altitude of the more considerable snow-fields on the 49th parallel, which, on the north and west sides of ordinary summit-peaks lie all the year round to a considerable depth, may be stated generally at 7,000 feet. Some of the glaciers come down lower, though none, at present, extend into the valleys proper. They are all of De Saussure's class of summit-glaciers.

Line of Vegetation.

This is not much more clearly marked, for it seems limited rather by the existence of soil than by elevation. Mr. Custer found Alpine plants and mountain grasses as high as 8,000 feet. The forest-line, however, is more distinguishable, and his observations and measurements lead to the conclusion that the line where timber, properly speaking, ceases, is remarkably uniform throughout the whole western Cascades.

The disappearance is very rapid, the trees retaining quite a large size to within a short distance of the point where they dwindle down into shrubs. It is noticeable that they extend farther up the western and northern than on the other sides of the mountains. The elevation of this forest-line may here be placed at 6,500 feet.

Lieut. Kautz, as mentioned below, found pines at a much greater height on Mount Rainier, viz., 7,268 feet; but this was probably due to local circumstances. East of the Skagit River, and thence through the interior basin, it attains, I think, a higher point than the average above given, notwithstanding the increased cold.

PRAIRIE-GLADES.

The distinguishing feature of the eastern slope of these mountains is the number of prairie-glades covered with grass, and, in the summer and early fall, blooming with a great variety of flowers. On one of the summits which I ascended, overlooking the valley of the Skagit, and elevated about 6,000 feet above the sea, these open tracks extended for a considerable distance, bounded only by the ragged crests and ridges of the interior range, in which were inclosed snow-basins and glaciers, the heads of numerous torrents tributary to that river. From an elevated point, a sea of mountains stretched in every direction as far as the eye could reach. To the south and south-west was the great mass of the Cascade range, Mount Baker being distinct among the rest.

Eastward, beyond the Skagit, the mountains presented a different aspect. They were of far more uniform height, with very few prominent peaks, and a general elevation of perhaps 5,500 to 6,000 feet.

They are also more bare of timber than in the western or main range. This equality of elevation, however, did not extend south of the parallel where Hozumeen and other naked serrated points reared themselves to a level with the summits of the Cascades proper.

GLACIERS.

Separated from this standpoint only by a deep gorge was a glacier, which formed, at the same time, the head of the Manselpannik and of another stream running to the Skagit. It seemed to be a half mile in extent, occupying the northern slope of a walled basin, and having an apparent inclination of 30°.

The termination was abrupt, and, as I judged, at about 5,500 feet above the sea-level, or 1,400 feet over the Manselpannik, to which a steep talus of débris led down. The field was mostly covered with snow, the blue ice showing chiefly at its edge. Numerous fissures ran

across it and divided it vertically. There was no arched opening for the water which ran down the rocks and gathered into a rapid stream below. Of the thickness of the ice I could form no opinion.

Mr. Custer saw on the Wailagonahoist Mountain, at the head of his Glacier Creek, a much larger one. The mountain itself he estimated at about 9,000 feet, on the side of which the glacier, somewhat interrupted, extended for about three miles. Its slope appeared to be as much as 70° and the vertical height covered by it 3,000 feet. It, in fact, reached entirely down to the valley. The stream here issued from a single vault and of considerable size, the water being of a whitish or milky blue. Numerous cascades from the adjoining mountains added to its volume.

In this neighborhood, also, the open glades occurred on the summits. They were rolling with gentle slopes, and inclose basins and shallow depressions, or extend down into the heads of gulches, from which arise small streams.

The glacial region has here undoubtedly been of almost Alpine extent, for these glades, in their surface, give evidence of the action of ice, at a period, geologically speaking, not very remote.

The snow, which falls to the depth of twenty or thirty feet, still lay in the middle of August in patches, especially in the basins.

Elsewhere it had so recently disappeared, that the grass was either dead or just recovering its verdure. I noticed in one of the depressions where a very distinct though small moraine had evidently been ploughed up.

On this mountain the first red snow was noticed, afterwards also seen on the mountains east of the Skagit. The coloring matter, probably *hematococcus invalis*, was so abundant that, in crushing a handful, the water exuding was reddened, as if with blood. On examination with a pocket-lens, the organisms which furnished it

appeared of a tadpole shape, or with a large rounded head and attenuated tail.

It is probable that at least the tributary valleys, such as those of the Chuchchehum and Manselpannik, have been the seat of more extended glaciers, though the dense forest might conceal the moraines which they would have left.

As, however, the level and terraced bottom of the Skagit, in the valley below here, where, from the more scant vegetation, the existence of moraines would be traceable, does not indicate their having reached it, and as no boulders are scattered over the surface, another proof is afforded that, since the glacial period, a subsidence of the land has admitted the entrance of the sea into the interior valleys, and, in modifying and arranging the drift, has covered also the débris of the glaciers.

VOLCANOES.

The only ascertained volcanic mountain in the Coast range of Oregon or Washington Territory is Swalalahos, or Saddle Mountain, about fifteen miles south of the Columbia River.

Its height, as compared with those of the Cascade range, is insignificant, and it has apparently been long extinct. It is composed almost entirely of conglomerate, and no lava streams appear to have issued from it, though it contains dikes of basalt. The crater is said, by Prof. Dana, who examined it, to be about two miles wide, and apparently 500 feet in depth, and is now covered with forest.

In the Cascades, the line of snow-covered summits which crown the range, and all of which are or have been the seat of volcanic action, has attracted the attention of every Western traveller. Of those south of the Columbia, Mount Hood only will be here referred to. Several of the others have been described by Dr. Newberry in his report on the geology of Lieut. Williamson's expedition.

In crossing the mountains by the emigrant-trail, some years ago, I made a sketch of the crater of Mount Hood, which accompanies this report. It faces the south, the wall on that side having been broken down, and is occupied by a snow-field. This mountain was first ascended by Capt. Gordon Granger, of the Regiment of Mounted Riflemen (now Major-General), in 1850, who reached the crater, but not the highest pinnacle. A second ascent was made in 1854. Of a number of persons composing the party, Mr. Thomas J. Dyer, of Portland, Mr. Wells Lake, and an Indian named "Cockup," alone reached the summit. The last was excessively proud of his exploit, as having overcome a superstition of his tribe.

Steam was visible in many places, escaping from small blow-holes in the crater, and ashes of a reddish color were collected, which, from their dry and pulverulent substance, were apparently recent. No glaciers were seen in the deep ravines which form the heads of the streams. Stumps of trees, weathered but undecayed, were abundant above the line of present vegetation, a fact very probably connected with the cooling of the mountain.

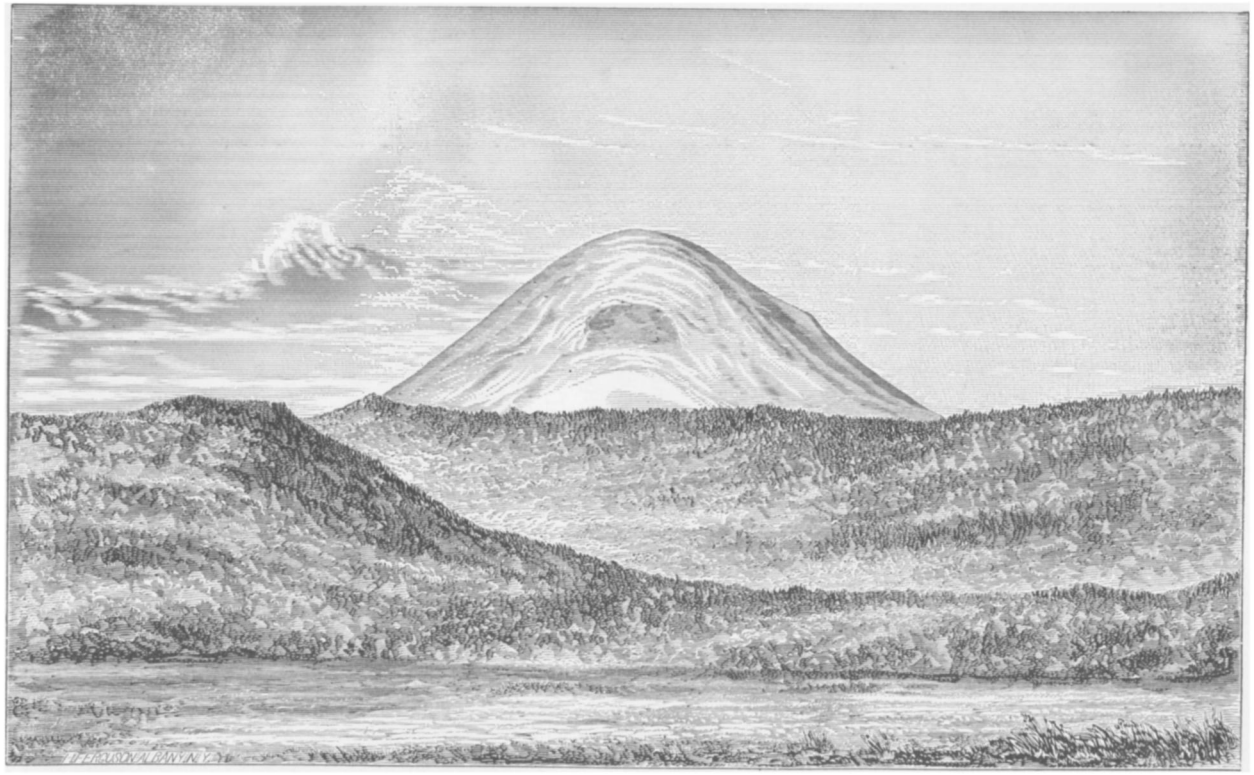
Mount Hood, though undoubtedly the highest of the range, is not visible from the ocean, owing to the intervention of the Coast range. From the plains to the east, and from Fort Vancouver below, it is a conspicuous landmark. Its general form is pyramidal, its sides exhibiting prominent ridges or foldings, but not so regular as those of Mount Rainier. The great discrepancy in the elevations assigned to these mountains by different writers is noticed by Humboldt.* Those familiar with all of them assign the supremacy to Mount Hood. Its probable elevation is 14,000 feet.

North of the Columbia River, and nearly equidistant from it, are two peaks, for a long time confounded with each other, Mount Adams and Mount St. Helen's. Of

* Cosmos, vol. v.

these, the former is nearly on the line of the general range, the latter some forty miles to the west. Both are situated on a broad plateau of mountains, the Cascade range having here its greatest width. The two peaks have nearly an equal height, and are probably not under 12,000 feet. Mount St. Helen's is visible for a considerable distance off the mouth of the Columbia, and at various points on the river as far as the Cascades; Mount Adams from the plains, and in most situations they bear a considerable resemblance to each other. St. Helen's is, however, much the more regular in outline, having a dome-shape, as exhibited in one of the accompanying sketches. Views of these two, and of Mount Hood, taken from the summit of the pass at Chequoss, give an excellent idea of their surroundings. No modern eruption of Mount Adams is recorded, but its former discharge of lava must have been copious, from the streams seen by Capt. McClellan's party, in crossing the range, near its foot. Mount St. Helen's is still active, though it has ceased to emit lava; its flow of this material was, however, apparently much later than that of its fellow, for one very extensive field, evidently proceeding from it, was seen, as clear and sharp in its fractures as if but just cooled. Smoke and steam are seen frequently to arise from near its summit, and considerable eruptions of ashes have occurred as late as 1842 and 1843. Fremont mentions that in November of the latter year "two of the great snowy cones, Mount Rainier and St. Helen's, were in action. On the 23d of the preceding November, St. Helen's had scattered its ashes like a light fall of snow over the dalles of the Columbia, fifty miles distant." Other travellers put the dates at 1841 and 1843. Fremont is, however, in error concerning Mount Rainier. It was Mount Baker that was then in action. Mount St. Helen's was ascended by Mr. Dyer in 1853.

The most prominent mountain, in going northward, is Mount Rainier. It is situated on the western side of the



DOME OF MT. ST. HELENS—FROM CHALACHA PRAIRIE.

range, and is visible from the east only on the lower part of the Yakama valley. In other directions, it can be seen from the mouth of the Willamette, from the coast of Shoalwater Bay, and from Port Townshend. It is, however, from the plains near Steilacoom, on Puget Sound, that it exhibits its full grandeur.

It seems to spring from the very level of the table-land, and though sixty miles off, "as the crow flies," appears at times, in that pure atmosphere, as not distant an hour's ride.

The probable height of Mount Rainier is between 13,000 and 14,000 feet; that of the general range being from 5,000 to 6,000 feet, and the adjacent mountains rise towards it in an easy curve.

The outline is bell-shaped, modified on the summit into three rounded prominences, which perhaps inclosed the ancient crater.

The sides are deeply striated by ravines of immense depth, separated by rugged and precipitous spurs. Like all the others of that range which I have seen, it has upon one side a shoulder, probably marking a former lateral opening or crater; of this, the most noticeable instance is on the Shaste Butte of California, where it takes the form of a truncated cone, engrafted upon the side of the mountain. Mount Rainier seems to have been extinct for a long period; at least no recent lavas have been observed in its neighborhood, and there is no tradition of its having been seen to smoke.

It has never been ascended to the summit; but an attempt was made in 1857, by Lieut. (now Major-General) A. V. Kautz and Dr. R. O. Craig, United States Army, who reached an altitude of 12,000 feet, as calculated by the boiling-point of water. They estimated the line of perpetual snow at 8,000 feet. There were no dead trees above the present line of vegetation as described by Major Haller on Mount Hood, and they saw no evidence of modern eruption. On its side Lieut. Kautz dis-

covered a glacier, the source of the Nisqually River, of which he gives the following account:

"The glacier from which the Nisqually rises is formed by the filling-in of an immense mass of snow and ice in a ravine on the south side of Mount Rainier. From where the river emerges to the head of the ravine the distance is four or five miles, and the latter varies in width from half a mile to a mile. The upper end is covered with snow, having immense chasms running across it. The lower end is principally ice, with much débris of rocks, sand, and gravel. It is about fifteen miles to the summit of Mount Rainier, from the foot of the glacier. The ravine narrows near its foot, and there is no terminal moraine, but there are lateral moraines, and a straggling medial one.

"The latter is not at all marked, but the lateral ones are very perfect, forming a ridge on each side 200 feet above the ice, with a slope of 60° or 70° next to the glacier, and about 45° on the other side. It is composed of the débris of the mountain, almost entirely of basalt rock.

"There is a large vein of granite at the foot of the glacier, through which it had evidently worn a passage, as the bed of the stream, for a mile and a half or two miles below, was white with granite boulders.

"The Nisqually came out from beneath the ice in a stream twenty-five or thirty feet wide, a torrent so muddy and rapid that we would not have dared to ford it. The cavern was not much wider than the stream, and about fifteen feet high. The ice was, in places, clear and blue, but in others mixed with débris."

The foot of the glacier was steep, but higher up it had a more gentle slope of perhaps one foot in five. We ascended about half-way and crossed over to the moraine on the west side, finding, with much difficulty, a camp

among the pines. Here the water boiled at 199° Fahr.,* and the thermometer stood 34°. The glacier made a terrific crushing and grinding noise during the night. We had snow all around us, but afterwards found that we could have gone 100 feet higher and obtained wood. From this camp we started at eight in the morning, and, travelling steadily till six, we had to return without the triumph of standing fairly on either peak, though we were on the top of the mountain. The summit of Mount Rainier is a ridge forming two sides of a triangle, with a peak at each end and one in the angle. We made the south peak nearly, and I could have easily reached it but for want of time. There is no indication of any recent eruption, and we saw no crater. If there is any, it is filled up with snow.

Mount Baker, the next most prominent peak, and the northernmost in Washington Territory, is fully twenty-five miles to the west of the water-shed of the Cascade range, upon a spur or offset, and about in a line with some other peaks to the southward, as Pitt Mountain and Mount Shaste. Its height is given by the United States Coast Survey approximately at 10,800 feet. It appears from the westward as a conical peak, less simple in form than any of the others.

From Frazer River, above Fort Langley, and also from the Skagit, it is seen to be truncated, or rather roof-shaped. It would seem to have only recently resumed its activity; as I am informed, both on the authority of

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* Altitude, Kautz's encampment, by Loomis's formula:

Barometric pressure, corresponding to 199°		22.971
Assumed sea level		30.042
Assumed altitude	7011.4	
Correction for temperature	234.0	
	7245.4	
Correction for decrease in gravity	23.0	
	7268.4	

officers of the Hudson's Bay Company, and also of Indians, that the eruption of 1843 was the first known. It broke out simultaneously with St. Helen's, and covered the whole country with ashes.

The natives told Mr. Yale, chief trader at Fort Langley, that the Skagit River was obstructed in its course, and all the fish died. This was, in substance, what they assured me on my visit to the river, adding that the country was on fire for miles round.

The fish, undoubtedly, were destroyed by the quantity of cinders and ashes brought down by the Hukullum. Since the above date, smoke is frequently seen issuing from the mountain.

Between Mount Baker and Mount Rainier a number of lesser peaks, presenting from the Strait of Fuca the form of a broken sierra, rise to the limits of perpetual snow. They have never been explored, but they appear, from some points of view, like the skeletons of formerly more elevated volcanic mountains.

I have heard of no volcanic peaks as existing in the Cascade or Marine range of British Columbia, but this development in the Russian dominions is extraordinary.

Sir George Simpson states* that eighty-four different volcanoes have been in operation, in the country under the jurisdiction of the Russian American Company, within the recollection of many of the inhabitants.

EARTHQUAKES.

These have evidently been of frequent occurrence, as they do not excite much astonishment among the Indians. Duflot de Mofras mentions one which was felt at Fort Vancouver, December 2d, 1841, at 4 P. M. They experienced these oscillations, of a second or more, and in a direction north and south. Mr. Yale, in a letter to me, says: "We had two that might have attracted the attention of the geologist. Both occurred after the eruption

* Overland Voyage.

of Mount Baker. The first was tremulous, and caused some dilapidation of tottering things; but its greatest peculiarity was perhaps the loud report that preceded or attended it, and the roaring noise, which continued for some time. The adjacent mountains being composed of tremendous masses of solid rock, we almost expected to behold them and ourselves sinking into an abyss. The other was undulatory, and did some injury to the foundation of our house. It seemed to have come from the westward, and to have left in its trail a cold, disagreeable, smoky vapor. Both occurred in winter. That of the 26th of December was felt here, but I believe slightly, having escaped my perception."

This last was one of December 26th, 1856, which was very perceptible at Port Townshend, where I then was, jarring the house like the fall of some heavy body. It was felt by Mr. Warbass at Whidbey's Island, and the Indians told him, in reply to his inquiry if they knew what it was, "that the earth was rising."

A very distinct shock was noticed at Olympia on the 2d of April, 1859, at 2:30 A. M. Mr. James Tilton, Surveyor-General of the Territory, describes its force as about equal to the effect of a sixty-mile-an-hour gale upon a frame house.

The crockery rattled, and many persons were awakened. There was but one shock, which lasted eight or ten seconds. The night was calm, and the tremor well defined, undulatory, and suggestive of the motion of a ship at sea.

A lady living in Olympia informed me that a pivot glass in her bedroom was made to swing so much as to attract her notice.

The direction was S. W.

Eastern Cascade Ranges.

The mountains lying between the Skagit and Okinakane, I have distinguished on the profile as the Skagit

and Similkameen ranges; but, excepting that each forms a watershed, more or less continuous, they do not possess the character of true ranges, but rather a confused assemblage of ridges with no perceptible arrangement or direction.

North of the parallel, they have a pretty equal height, not exceeding 6,000, or at most 6,500, feet above the sea, and on the summit and southerly exposures they are thinly wooded and covered with grass. South of the line, however, they are much more elevated, rising in high and ragged peaks, of which Mount Hozomeen, standing almost exactly upon it and overlooking the Skagit, is an example.

Between that stream and the forks of the Pasayten, the rocks generally were of the same character as in the Cascade range.

The divide between the two rivers was of felspar, interstratified with slate and quartz. Descending the west fork of the Pasayten, they were granitic, sienite, as usual, prevailing over true granite.

Quartz, felspar, diorite, and various porphyries also occur. In a small branch of this fork, boulders of sandstone, containing some vegetable traces, were observed; and on the mountain opposite the Chuchuwanten the rocks were sandstones, of various degrees of fineness, and conglomerates.

It is not improbable that tertiary deposits of some extent have existed here, as Lieut. Parke found lignite, in a micaceous sandstone upon the Similkameen, a little above the mouth of the Pasayten; but, if so, they have been mostly denuded or greatly altered.

The valley of the west fork has quite a gradual descent, but nowhere exceeds a mile in width. It is divided into basins, irregularly lined with terraces, some of them level and rising in benches, others resembling rather slides from the mountains, subsequently modified by water, than original deposits. The soil is of fine sand, mixed

with gravel and boulders. The south fork is more rapid, and with a narrower bottom, and below the junction the river enters a cañon, which continues to near the mouth. Crossing from the Pasayten to the Similkameen, porphyritic and altered rocks formed the mountains dividing the former from the Naisnuloh, and prevailed for some distance down the last-named stream. Below these, sienite, quartz, and blue slate were observed, sienite constituting the prevalent boulders in the stream. The quartz, in many instances, breaks into polyhedrons, huge modified crystals, often weighing over a ton. In one of these, which had been fractured, I noticed three sides of an interior hexagonal prism. In places, steep escarpments of the mountains overhang the Naisnuloh, a talus of débris resting against their sides, the fragments of which were often of great size.

The terraces on the Naisnuloh were a strongly-marked feature, occasionally attaining a height of 300 feet above the stream. They occur sometimes on one side only; at others, on both, and of equal elevation. Longitudinally, they appeared perfectly horizontal, but with a slope from the mountains towards the water. In its lower course, the Naisnuloh, as is so generally the case with these rivers, becomes more rapid, and the valley narrows. The cañon continues till within two or three miles of its mouth, from whence to the Similkameen is a level-terraced plain.

Mr. Custer, who crossed from the Skagit on to the head of the Similkameen and thence descended the latter, found the divide to consist of sienite and slates, and these rocks prevailed along his route. From the Campe des Femmes to the mouth of the Haipwil the river is nowhere very rapid; but its valley, down nearly to the mouth of the Naisnuloh, is narrow, not exceeding from half to three-quarters of a mile. From the junction of the Pasayten fluviatile terraces line the bottom.

Below the Naisnuloh the prevalent rocks were sienite,

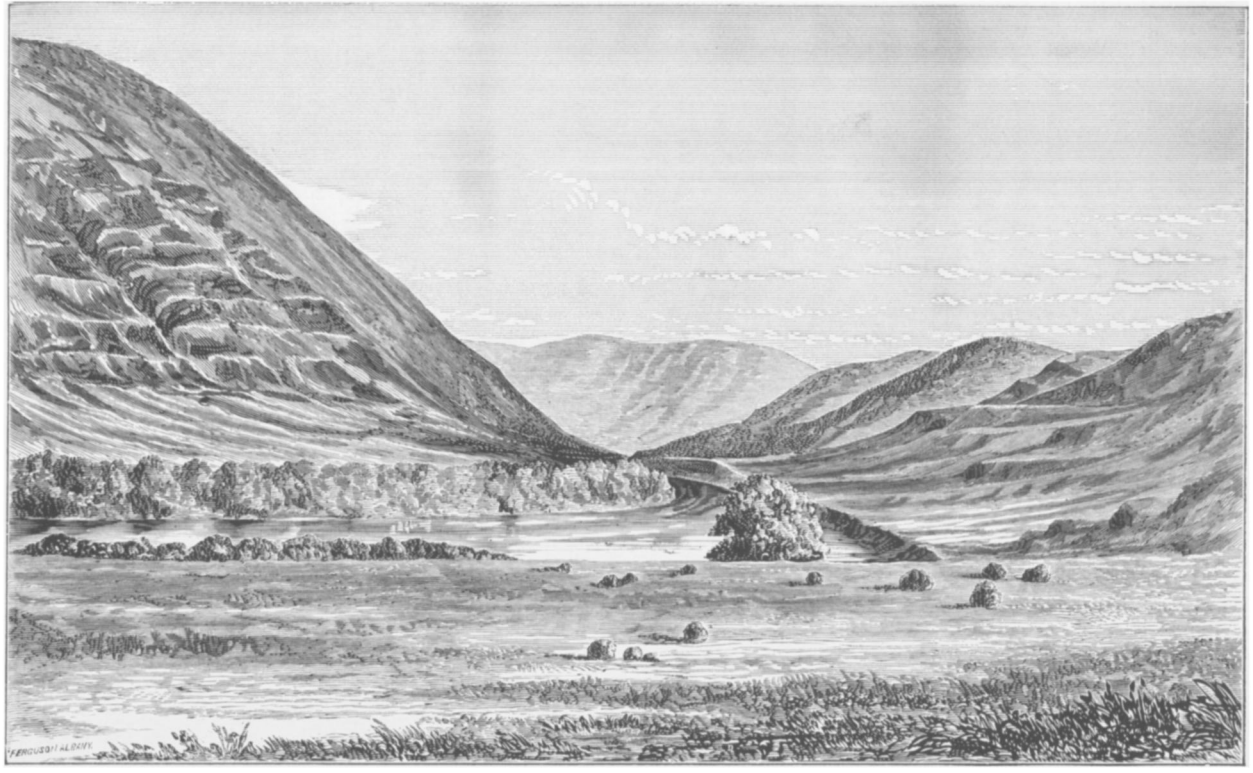
hornblende, and lamellar quartz, all greatly disturbed in their position. At the mouth of the Haipwil, alkaline deposits were first noticed in the residuum of a shallow lake which had recently dried up. There were no crystals, but the salt covered the ground in a thick effloresced crust, which at a short distance presented, as on the Sweetwater River, precisely the appearance of water, or rather of ice, surrounded by an edging of snow. The soil generally throughout the lower valley of the river seems more or less impregnated with it. This basin is nearly destitute of timber, and of but little value except for grazing. A few patches of wet and rich bottom occur, but for the rest it is all sandy; and the presence of the artemesia and the cactus would alone be sufficient proof of its worthlessness.

The mountains are sparsely timbered, and, where not denuded of soil, are covered with fine bunch grass, as are also the terraces and much of the bottom. Their slopes are generally steep, deeply furrowed by ravines, and broken by rocky escarpments, from which masses of débris extend down to the valley.

The district suitable for settlement, therefore, is of very limited extent, and that lies altogether north of the parallel. For summer grazing it is admirably fitted; but although the snow, according to Indian report, does not lie as deep here as it does on the Columbia, and their horses can contrive to subsist, it is evident that in this climate no considerable number of animals could be wintered without an artificial supply of food.

The terraces on this part of the river, and for some distance below, do not exceed thirty or forty feet in height, and extend in long level lines for miles at a stretch, the faces curving with the course of the stream.

They are not always found on opposite sides, but sometimes alternate. The normal surfaces seem to have been almost flat, but the wash from the mountains has left long sweeping slopes, sometimes extending to the edge,



SKETCH ON SIMILKAMEEN RIVER—MOUTH OF HAIPWIL.

sometimes but part way, according to the width of the plateau.

Upon some of the hill-sides are partially terraced banks, frequently extending to a considerable height, as, for instance, at the junction of the Haipwil.

A little below that stream, the terraces are greatly modified, both by erosion and by increment of detritus from the hills. Deep arroyos have been formed, the level bottom ceases altogether, and a few miles farther down, the river becomes cañoned, and presents a succession of rapids and falls, one of which is some twenty-five feet in height.

Approaching the mouth, the Similkameen valley again widens out into terraces or plateaux, which are conspicuous where it unites with the Okinakane.

The general rock of the hills, between the bend of the Similkameen and the Okinakane, are sienite and lamellar quartz, interstratified with slate. Mica schist was also noticed. In the cañon of the river, slate and quartz prevail, having a general dip to west and south-west at varying angles.

Overlying the sienite, on many of these hills, is a coarse conglomerate, containing large imbedded fragments of granite.

There are also some sandstone and indurated clay rock, which appear to be the remains of a tertiary deposit, as in a fragment of sandstone I found a dicotyledonous leaf, which Dr. Newberry has recognized to be of that age.

Unfortunately I had no opportunity of extending the search at this place.

It was in the cañon of the Similkameen that the discovery of gold, by some of the party, created one of those epidemic excitements common on the Pacific. During the halt of the commission at Camp Similkameen, some of the men, in prospecting, struck diggings on a low bar in the river, only a few rods long. The following day a sergeant belonging to the escort obtained

six dollars and twenty-five cents from nine pans of dirt, and one of the employés about ten dollars in an hour.

Subsequently two men washed thirty-five dollars in about half a day, and others various amounts, many of them approaching the above. All this was got merely by panning. The bar soon presented an amusing scene; soldiers, employés and Indians being engaged together, and all sorts of implements, from a tin cup to a frying-pan, being brought into requisition. The gold was in coarse scales, sometimes in pellets and pieces weighing several dollars. After our departure one piece was found weighing twenty-two dollars and fifty cents. The gold had every appearance of being washed down from the neighboring gulches, and the probability of this seems to have been confirmed. It may be remarked that in 1853 Capt. McClellan's party found "the color" in small particles, in surface-sand, upon all the streams emptying into the Columbia from the Cascades, and at the mouth of the Similkameen in perceptibly sharp and unwashed points, indicating a neighboring origin.

During the winter and spring of 1859–60, a considerable number of miners flocked to this neighborhood, and extended the search to the Okinakane and the Nehoialpitkwa. Owing to the physical features of the country, perhaps, more than to a deficiency of the metal, the Similkameen district was soon abandoned. The want of water upon the hills prevented sluice-washing, which alone could be permanently productive. Scattered diggings which were found upon the Okinakane likewise failed, and the only ones occupied for any length of time were those of Rock Creek, a branch of the Nehoialpitkwa, presently to be noticed. Native copper is said to have been found by the Indians in the mountains near the forks, but I could procure no specimens of it. Stains of blue carbonate of copper, in seams of quartz, were found near Lake Osoyoos, and a fragment of quartz containing galena was picked up on the Similkameen.

The geological character of the country above described prevails, according to the observations made in the expedition of 1853, through the whole of that between the Cascades and the Columbia, as far south as the Winatsha or Pisquouse River. Granite rocks, gneiss, slates, and various porphyries continued, so far as I saw, to the exclusion of basalt and basaltic conglomerates, and also to that of unaltered sedimentary deposits, except as here mentioned. I have made no attempt at their arrangement in order of supposition, though I presume the granites to be the lowest part I have seen; almost every one passes, by invisible gradations, into others.

A striking change in scenery appears in descending the Similkameen. The valley of the river, as already mentioned, is almost destitute of timber, a few scattered pines alone appearing upon the terraces, with an occasional skirt of willows along the stream. The lower hills, particularly their southern faces, are also bare of forest. The whole of the eastern Cascades, in fact, present a dry and arid appearance, as contrasted with the moist fertility of the western range.

Okinakane Valley.

Sienite, gneiss, and granite are the prevalent rocks of the Okinakane below the mouth of its principal tributary. Above that point, the same rocks were capped with the coarse conglomerate noticed on the Lower Similkameen.

At the lower end of the great lake, claystone porphyry was noticed. Very little of this valley is fitted for cultivation, as the soil is sandy, with alkaline deposits. Timber is confined to the mountains, except a few cottonwoods and willows in the bottoms.

The Okinakane, as well as the Upper Columbia and Frazer rivers, is remarkable for its fluviatile lakes, formerly still more numerous through this northern country, but the most of which have been drained by the

gradual wearing down of the river-beds. These, indeed, were but the remains of those arms of an interior sea which extended up into the narrow and trough-like valleys between the mountain-ranges.

The largest of the Okinakane lakes is over sixty miles in length. Between it and the forks of the Similkameen are four smaller ones, and its valley, below that point, is divided into basins, where others once existed.

I have assigned all the mountains west of this river to the Cascade system, as will be seen hereafter. The trough or valley of the Okinakane is nearly 400 feet lower, on the forty-ninth parallel, than the Columbia River at the same latitude; and the difference in altitude between the great lake and the upper Arrow Lake of the Columbia, a degree to the northward, is probably as much. This stream, therefore, forms the true trough of the interior basin. Its course, which is from north to south, is continued by that of the Columbia, from the junction to the mouth of the Snake, near Walla Walla. As usual, the descent of the Okinakane is more rapid on its lower than its upper portion.

The terraces of this valley are among the most noticeable features of the region, and it is in this neighborhood that the coulées, or, as termed by Lyell, landstraits, are almost strikingly exhibited.

As they will be noticed in a separate chapter, I shall not particularly describe them here. The general height of the lateral or river terraces was from 250 to 300 feet.

NEHOIALPITKWA RIVER.

From the first summit of the divide between the Okinakane and the Nehoialpitkwa, elevated about 2,200 feet above the former, a view opens to the south-west and west, as far as the range bordering the Methow River, and the Tchopahk Mountain on the Similkameen. The scenery has a desolate character from the barrenness of the hills and the yellow hue of the herbage. Except

where escarpments of rock project, the slopes of the mountains near the river are gradual and the lines of terraces well marked. The actual summit is about 1,000 feet higher, being over 3,000 feet above the Okinakane, or 4,067 above the sea. It maintains the same character of grassy slopes and plateaux with skirts of timber, and, on the highest points, forest. Terraces and knolls continue to the top, the former having an amphitheatrical arrangement.

The divide between the two rivers, like that between the Skagit and Similkameen, is very narrow; the Schainks, the western branch of the Nehoialpitkwa, heading within a few miles of Lake Osoyoos.

The character of the Nehoialpitkwa, a secondary stream, is a miniature of the larger ones. The main river runs southerly to the neighborhood of the parallel at the junction of the Schainks; thence, turning easterly through a valley formed of a series of basins, it receives its two principal feeders also from the north, and, then bending suddenly nearly south, reaches the Columbia opposite Fort Colville.

The lowest of the two main tributaries is the outlet of a long fluviatile lake. None of any consequence come in from the south. As usual, it is cañoned at its lower extremity.

Central Range.

The mountains between the Okinakane and the Columbia, on both sides of the Nehoialpitkwa, rise to an average height of 6,000 and 6,500 feet, with occasional peaks 1,000 feet higher. Their summits are broad and flat, the ascents very gradual, though broken by escarpments of rock. On the right bank of the river they are often denuded of soil, but still show in horizontal lines of the larch, or tamarack, the remains of elevated terraces. These trees are, in the autumn, conspicuous among other coniferæ by the yellow hue which their leaves assume

before falling; and, perhaps from their requiring a greater depth of soil than the firs, seem particularly to affect the terraces and summits. The southern and eastern slopes are less timbered and more grassy than the others.

The terraces throughout the valley are well marked. The descent to the Schainks is by four of these benches, the heights of which, above the crossing of that creek, were, of the first, 767 feet, of the lowest, 363 feet; or, respectively, 3,452 and 2,685 feet above the sea. In the basins of the main stream they are lower and more extensive; but at the mouth again, where the fall is more rapid, they regain their height. Modified terraces are visible in various places at from 500 to 600 feet above the river. The débris and wash from the hills form slopes towards the river, sometimes at a pretty steep angle, extending to the edge, or crossing midway in the terrace, according to its width. Large masses of rock are scattered over them, but evidently all derived from the neighboring mountains. Almost every form of modification is to be found well marked along this river.

The rocks on the mountain-sides, to a great height, appeared often to have been smoothed by water or ice. If by the latter, it was possibly the ice of the arms or bays, and not of glaciers, though these may have been, as elsewhere, covered by detritus.

Many of the appearances of glacial action, attributed to fixed glaciers, may, it appears to me, be rather due to ordinary winter-ice, at a period of greater elevation of the water or depression of the land. I saw no transported boulders in this valley, though the terraces are often strewed with blocks rolled down from the adjacent hill-sides.

The geology of this range, which, following Prof. Dana, I have considered as a continuation of the Blue Mountains, is singularly confounded. Leaving Lake Osoyoos, we found, at the foot of the divide, sienite cropping out beneath quartz rock. The summit was of

a dark-colored granite, decomposing rapidly on exposure, and descending to the Schainks; besides the granite, boulders of blue altered slate and a porphyritic trachyte were abundant in the stream. In following the Nehoialpitkwa down, a great variety of rocks were observed,—granite, trap, porphyry, gneiss, and laminated quartz, talcose actinolite and mica schist, as also limestone. A short distance above the southerly bend of the river, on the right bank, the granite breaks through the gneiss, forming, as it were, dikes or long hogbacks running down the side of the mountain, and conspicuous by their lighter color.

Gneiss enters much more largely into the constituents of these mountains than it does into those of the Cascades. In particular, it forms the walls of the cañon near the mouth of the river, where it is nearly horizontal. The limestone, which becomes more abundant in approaching the Columbia, is thickly bedded, crystalline, and appears to overlie the others.

The search for gold upon this river, consequent upon its discovery upon the Similkameen, resulted in finding "diggings" upon Rock Creek, a stream coming in from the north, near the first crossing of the parallel, and to the foundation there of a village, or miners' settlement. The excitement was of somewhat longer duration than at the first-mentioned locality, but has since subsided in favor of the mines more recently discovered in the Nez Percé country.

The Nehoialpitkwa valley contains some land suitable for cultivation in the basins and low plateaux, but its chief value is for grazing. The best part of it lies north of the parallel. The timber in the valley itself is mostly the red or Columbia pine (P. ponderosa), larch, and yellow fir; on the mountains, the larch, pinus contorta, yellow and balsam firs. The line of forest reaches a greater elevation here than on the western Cascades. Mr. Custer found pines and balsam firs in full vigor at 7,000 feet.

COLUMBIA RIVER.

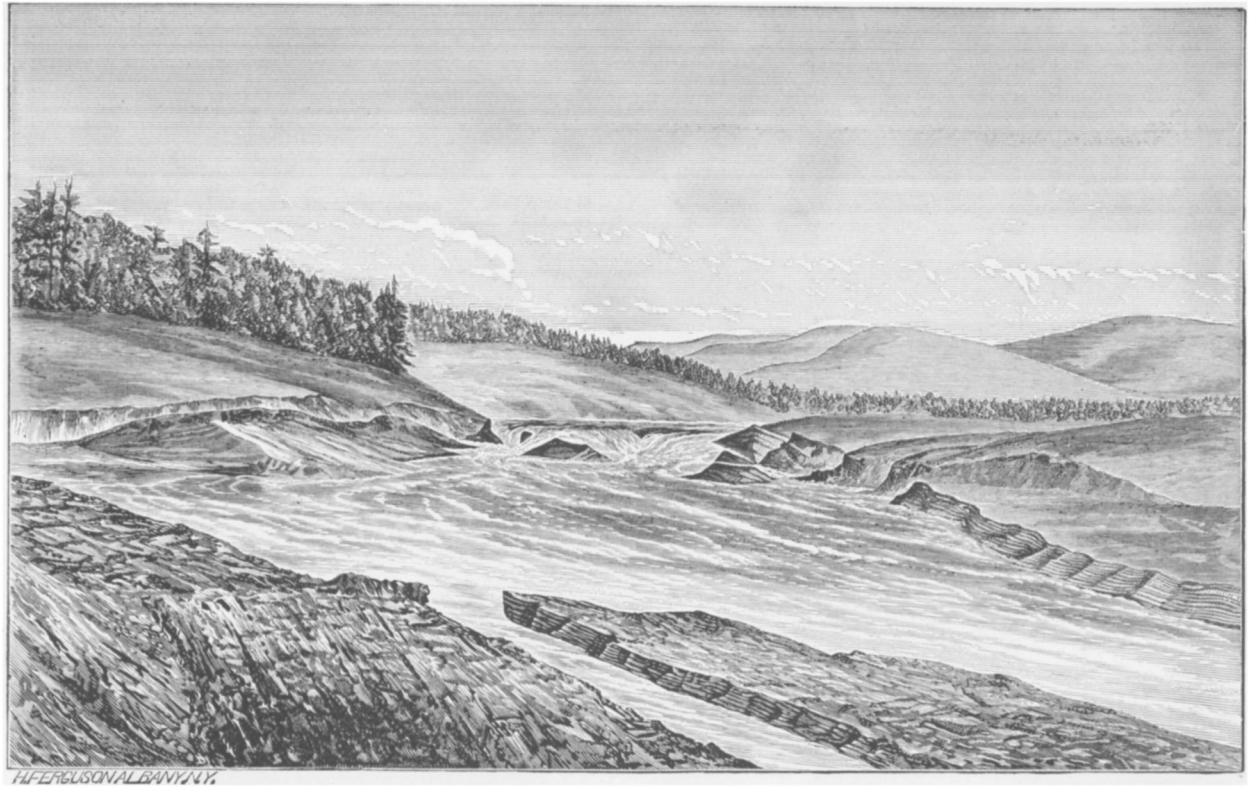
The falls of this river near Fort Colville (generally known as the Shwoyelpi, or Kettle Falls, from the "pot-holes" worn in the rocks) are about twenty-five feet in height. The obstruction is formed by a thick bed of laminated quartz, which here crosses the river, having an easterly dip of 20°. This spot is one of the great fishing-grounds of the neighboring Indians, who annually assemble, in the summer, in large numbers. The falls are not sufficiently perpendicular to stop the passage of the salmon, but check them enough to enable the Indians to secure incredible numbers.

Following the Columbia from Fort Colville to Fort Shepherd, a little above the forty-ninth parallel, slates and limestone prevailed, with intrusions of trap, and an occasional outcrop of granite. The slates were much broken up and altered, and no general dip could be recognized. The limestone was of various quality, the prevalent form being a fine-grained and compact black rock. It was also found breaking up into wedge-shaped fragments and splitting into large plates. This last was of various colors, pink, white, and dark gray. Near the mouth of Clarke's Fork the boulders were sienite.

Gold was found several years ago in Clarke's Fork, and in the Columbia, at its mouth, and this discovery led, I believe, to that of the Frazer-River mines. It was chiefly obtained from the bank, or lower terrace, and was very fine, requiring mercury to collect it. Farther up Clarke's Fork it was rather coarser. The prospects, however, were not flattering, and in 1859 the placer was already nearly abandoned.

Excepting the terraces, which are seldom of any width, the Columbia has no valley above Fort Colville. From there to the mouth of Clarke's Fork it is lined on both sides by hills of very uniform elevation, which sometimes, for miles, present an almost unbroken wall.

In the whole distance no tributary larger than a brook



FALLS OF THE COLUMBIA—NEAR FT. COLVILLE.

enters from the east, and on the west but a single stream, a creek called the Yornetsin, or White Sheep.

In the wider parts of the river-bed extensive flats and stony bars occur; elsewhere it runs through a trough of sloping boulders.

At Fort Shepherd, about a mile above Clarke's Fork, the rise of the river, as indicated by this trough, is twenty-five to thirty feet, and the boulders range from a foot to three feet in diameter. The tremendous force of the sand-laden water, during the freshets, is shown by the rocks in litter, which are polished and worn into deep kettle-holes, as they are at the falls below Colville.

About twenty-five miles above Fort Colville are the "Little Dalles," a narrow cañon in the slate rock, where the river is compressed to a width of perhaps fifty yards. This word *dalles*, by the way, which occurs frequently on the maps of Oregon, is a Canadian term, signifying a trough, and is usually applied to cañons in the bed of a stream, not to the great fissures or excavations through which its course lies.

The width of the Columbia at the mouth of Clarke's Fork is about 300 yards. That branch enters at right angles through a gorge in a wall of hills some 1,200 feet high.

Its course for many miles above its mouth is that of a roaring torrent, and it falls directly into the main river by a cascade of twelve or fifteen feet in height.

The terraces of the Columbia are well marked and continuous for considerable distances. At one camp below the mouth of Clarke's Fork the base was elevated about eighty feet above the river. From the opposite and corresponding one, the second rose to the height apparently of 500 feet, and still above that a line of larches indicated the remains of a third.

The lower terraces are wooded with pine, larch, and fir, and the two latter line the hills. The fact that these terraces do not slope with the river, but descend by

steps, is well illustrated between Fort Colville and Fort Shepherd.

FROM COLVILLE TO SINGAWATEEN.

The valley of the Slawntens, or, as it is locally called, Mill Creek, which enters the Columbia just below Fort Colville, and of the Chemakane, a small stream heading with it, and emptying into the Spokane, form another of the coulées before mentioned, of which there are a number running through these hills. The first rises from the base plain of the Columbia, by a terrace, to a height of some 380 feet above the river, and the divide between the two is between 500 and 600 feet, the Chemakane valley dropping by another terrace to the level of the Spokane. Of, course these streams excavate deep cuts at their exit.

The Mill Creek valley has been for many years occupied by employés of the Hudson's Bay Company, chiefly Canadians and half-breeds, and is, in fact, the only settlement in the central part of Washington Territory. Since the establishment of the depot by the escort of the Boundary Survey, however, quite a number of Americans have come in, and it would require the protection and encouragement of a military post, for a few years only, to give a character of permanence to the population. The soil of the valley is rich, consisting of a deep, sandy loam, with a subsoil of sand. That of the terraces is, as usual, gravelly, underlaid by blue clay at a depth of ten or fifteen feet, but the hill-sides are also capable of producing grain. The best crops, at present, are oats, barley, peas, and roots.

The wheat hitherto raised has been summer wheat, and the seed, as indeed that of everything else, has been suffered to run out. The new seed brought in by the troops, consisting of potatoes, beets, and other vegetables, produced abundant crops.

Winter wheat would probably succeed well, as the snow lies continuously, and would prevent freezing out.

Of the fruits, apples alone could thrive here. The nights in summer are said to be warm; but the season is very short, early and late frosts occurring.

The Chemakane valley, which was, at one time, the seat of a mission, also contains some very good land.

The limestone, which forms so prominent a constituent in the mountains west of the Columbia, appears to find its limit in the range of hills bordering it upon the east, none having been observed beyond the Slawntens and Chemakane. It here overlies quartz rock, which is, on the other side of the river, frequently laminated.

Around the depot, the quartz was chiefly visible in the western and north-western escarpments of the hills; and, at the mill at Peptahshin Creek, the dam is formed by a ledge of quartz dipping northward at a steep angle.

Boulders of sienite, some of them ten or twelve feet long, were noticed scattered over the hills east of the depot, a fact remarkable in connection with their scarcity through this country generally.

The explanation, I presume, is to be found in the fact that the valley of the Columbia, and the coulées which intersect these hills, admitted the passage of transporting ice, which the mountains elsewhere intercepted.

East of the Slawntens and Chemakane, and between them and Clarke's Fork, the rocks observed were a light-colored granite, sienite, gneiss, and quartz, the latter very generally either laminated or bedded. The granite itself was frequently divided by parallel planes, in such wise as to present the appearance of stratification, and in places separated into cuboidal blocks, so as to resemble a wall laid up in horizontal courses.

Upon the Spokane the basalt of the great plateau makes its appearance. This stream has been mentioned as the dividing line between the trap and the granite and other associated rocks, and substantially it is so; but the skirts of the former, nevertheless, cross it in places, overlying the granite.

The bluffs of basalt are often eroded into large rounded masses, and the rock, still farther disintegrating, falls apart in irregular pieces, forming mounds, from the summit of which points or chimneys of still coherent material project.

The terraces of the Spokane are conspicuous for their elevation rather than their number. They are formed almost altogether from the white quartz and felspar of the decayed granite.

Between the Little Spokane and the Cœur d'Alêne prairie, upon a plateau of trap elevated some 500 feet above the latter, an outcrop of argillaceous slate was observed overlying the basalt. The Cœur d'Alêne prairie, which is situated on the main Spokane, here called the Cœur d'Alêne River, is about twenty miles in length by three to five wide.

This valley, which is one of the most beautiful in the territory, is the favorite resort of the Indians of both tribes, who pasture their horses on the bunch-grass with which it abounds, and have their patches of grain and vegetables under the hills which border it. No great portion, however, is capable of cultivation.

The prairie is slightly terraced, and, in places covered with rolled gravel, precisely like that of sea-beaches. Its elevation is approximately 2,200 feet above the sea.

In the valley of the Little Spokane there is a considerable body of arable land, and wheat and potatoes both thrive well. The climate of the Spokane is much milder than that around Colville or on Clarke's Fork, and the season proportionately longer. The grass on the 3d of April was already becoming green, and early spring flowers were appearing, while at Colville depot the snow had hardly left the ground.

From the prairie, the Cœur d'Alêne Mountains, on the south, and Bitter Root, on the east, bound the river, both at this season topped with snow. The river, which, emerging from the lake, winds through the whole length

of the prairie, a little below it, makes a fall of 100 feet, the obstruction, according to Dr. Cooper, being gneiss lying horizontally, through which it has cut a narrow cañon, with vertical walls, a mile in length. Gneiss, granite, and pegmatite form the principal rocks on the north side of the prairie also, where they run into one another in the most confused manner.

The valley of the Cœur d'Alêne is connected with that of Clarke's Fork by a wide coulée, the greater part of which is a plateau, elevated some 600 or 700 feet above the former. It bears indubitable evidence of deposit or arrangement by water, and unquestionably, at some former period, opened a communication between the two.

This plateau is thickly wooded, and snow lay to a depth of two or three feet, deepest as we approached Clarke's Fork. On reaching Pekoula Lake, the route to Clarke's Fork descends an abrupt terrace of 225 feet, and follows a lower bench some fifty feet above the water. Beyond this the descent of the outlet was gradual to the Singawateen crossing. The ranges on either side of this valley rise to a considerable height, the shape of the mountains being in general of the rounded outline common to granite formations, in many instances with dome-shaped summits and crowning knobs, all wooded except on the highest peaks. On the west side, or towards Colville, one summit called Chekolesum, probably 7,000 feet in height and destitute of timber on the top, is the Ararat of the neighboring Indians, to which they fled in the great rising of the waters. Mr. Angus McDonald, of the Hudson's Bay Company, informed me that a petrified tree, said to be cottonwood, lies upon its summit.

Clarke's Fork, from the Katispelm Lake to Singawateen, a distance of fifteen miles, has itself almost the character of a lake, especially in the freshet season, its channel being wide and deep, and its current comparatively sluggish. From there to the old mission of St. Ignatius, thirty-five miles, it is swifter, and below that

point it runs through a cañon broken by falls and rapids, and impassable for canoes. Even the salmon do not ascend it. The only alluvial land below the lake is an occasional strip of meadow, flooded during the summer. The terraces are composed of a very stiff and refractory whitish clay, utterly unfit for cultivation. The country is everywhere timbered and vegetation exceedingly late, frost and snow not entirely disappearing from the woods until the end of May.

The rise of the south branch, at the junction of the Bitter Root and Hellgate forks, commences about the 1st of April; that of the north branch, on Flathead River, I could not learn, but it is undoubtedly later somewhat.

At Singawateen the rise commenced about the middle of April, and the water reached its stand-point June 17th, the height being sixteen feet. On the 17th August it had fallen to within four and a half feet of its spring level.

The rocks between the crossing and the lake were almost entirely granite, composed of light-colored felspar in large crystals, white quartz, and a small proportion of mica. Some gneiss and diorite were also observed.

Katispelm, or, as it is also called, Pend'Oreille Lake, is not an expansion of the present river, but fills a considerable valley transverse to its course. It is forty miles long by seven in greatest width, very deep, and lined on both sides by mountains.

A depression, or coulée, similar to that between Singawateen and the prairie, extends from its head, south toward the Cœur d'Alêne Lake, and another north from its lower end to the Kootenay, at Chelemta. This last is drained in either direction by streams which interlock with one another. It is continued directly north by the course of the Kootenay River as far as Flatbow Lake.

Barometric measurements give the following as the

approximate relative heights of these rivers and their connecting valleys on north and south lines:

Elevation of Cœur d'Alene Lake	2,230	feet.
Elevation of Katispelm Lake	2,210	"
Height of former over latter	20	"
Elevation of Spokane River at the prairie	2,170	"
Elevation of Clarke's Fork at Singawateen	2,140	"
Height of former over latter	30	"
Elevation of Katispelm Lake, as above	2,210	"
Elevation of Kootenay River at Chelemta	1,770	"
Height of former over latter	440	"
Elevation of divide between Cœur d'Alene prairie and Singawateen	2,580	"
Elevation of Spokane River	410	"
Elevation of Singawateen	440	"
Elevation of terrace opposite Chelemta	2,360	"
Elevation of terrace above Katispelm Lake	150	"
Elevation of terrace above Kootenay River	590	"

It will thus be seen that the elevation of the rivers decreases as we proceed northward, and that a comparatively slight erosion would direct the water of Katispelm Lake into the Kootenay. On the other hand, the terraced deposits, so far as observed, are higher at the northern than at the southern end of the coulées, as, for instance, at the Kootenay than on the Katispelm Lake, and this not merely in comparative, but in actual height. On the supposition of recession southward of the sea, this would be naturally the case.

From the configuration of the country, it would seem probable that other similar depressions, running in conformity with the mountain-chains, connect the Kootenay with the waters of Clarke's Fork above the points here mentioned, and these would appear to be natural valleys,

formed during the original upheaval of the mountain-ranges, and filled up by detritus during the submergence of the country. The remarkable feature is, that the rivers should have cut out channels through these ranges, instead of following the troughs.

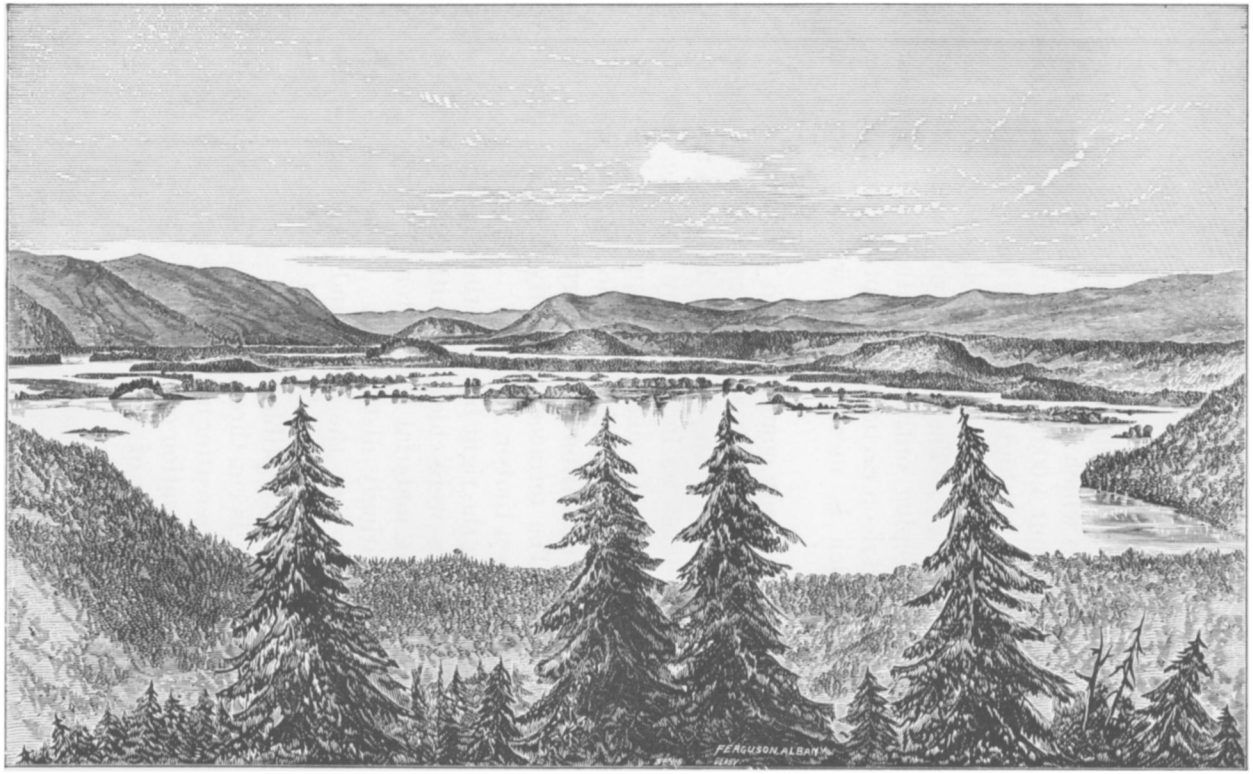
Mr. Darwin has noticed similar facts in some of the mountain-basins of South America.

Passing from the lake to Chelemta by this valley, we found the bottom-land heavily timbered, and the upper terraces, which are sandy, exhibiting the open grooves peculiar to the Red River. The mountains on either side are granitic; but in the bed of the creek, running through the Kootenay, were large boulders of sandstone, probably tertiary.

KOOTENAY RIVER.

The valley opens upon the Kootenay at a point where, having broken through a range of mountains in a course from east to west, it turns suddenly northward, as it were in continuation of the coulée. Looking down the river, from the high terrace in which the latter terminates, a superb view presents itself in the early summer; the entire valley, from mountain to mountain, being flooded, leaving only strips of more elevated timber-land, small islands, and the tops of trees above water. On the opposite or right bank, the course of the stream can be followed by the balsam poplars, and willows, which border it on either side, as it crosses nearly to the farther side of the valley, and there winds down in a serpentine course, presenting the curious spectacle of two parallel rows of trees rising in a broad expanse of water and inclosing a canal.

It is such immense reservoirs for the melted snow of the Rocky Mountains that supply the body of water which continues to pass through the Columbia and Frazer rivers until late in the season. The accompanying views, one taken from the point of our first approach during the freshet, and the other some twenty miles



KOOTENAY VALLEY IN THE FRESHET—FROM OPPOSITE CHELEMTA.

below, after its subsidence, will give a better idea, however, than mere description. The valley is from two to five miles wide. The terrace, which here borders it, is single, and rises to a height of 500 or 600 feet, but on the right bank is greatly modified and broken by the protrusion of the rock on which it rests. The mountains reach an elevation of about 4,000 feet above the river, or 6,000 above the sea, some higher points being above the forest-line. Patches of snow are visible upon them till the beginning of July. They are massive, with moulded summits and sweeping outlines, but their sides present many abrupt and deep ravines. Except the river-bottom or interval, which is meadow, the whole country is timbered.

The river had already commenced to fall, and, as estimated from the banks, the subsidence had been about nine feet. The difference at Chelemta between the highest and lowest stages, as indicated by a gauge, is little short of thirty feet. As might be supposed, there is no arable land in the valley, those portions where the soil might admit of cultivation being overflowed during the early summer. The terraces are sandy, but afford good grazing in the open timber.

Following down the right bank of the Kootenay to the parallel, the rocks were chiefly granitic, varying in the proportions of the material at different localities, mica being always sparingly distributed. Some gneiss was also noticed. Leaving the river and crossing to the Moosyie, a change in the geological character of the country is at once perceptible.

The range which is cut through by the Kootenay in its great bend, as will hereafter more particularly be noticed, is a northerly continuation of the Bitter Root chain, and as such the true axis of the Rocky Mountain system, though not its watershed.

It forms the divide between the crystalline and metamorphic rocks of the western side and the stratified rocks

of the eastern ranges, though here the latter are themselves much broken up, and, to a great degree, metamorphosed. Of their age and relative position I could form no positive opinion. I found no fossils whatever, but in lithological character they resemble those of the eastern mountains. Stratified quartz, blue and green slates, sandstone and limestone,—the last, apparently, uppermost,—now overlie granite and diorite.

All these are greatly upturned, and no consistent dip could be ascertained. This character prevailed to the head of Moosyie, in about lat. 49° 30′.

The valley of this stream is very narrow, and lined with rocky-timbered hills. It has the character, so often referred to, of being flat and sluggish at its source, with marshy ponds,—lower down rapid, and cañoned at its mouth.

The terraces are marked throughout, and, which is rare to the westward, strewed with boulders and irregular blocks. The Moosyie Lake is simply an expansion of the stream, pretty, but with no marked features, and divided by marshes. The hills on each side are some 1,200 or 1,500 feet above it, rising in rocky benches, sandstone being the prevalent constituent.

On the right bank are very regular walls of strata, varying in thickness from an inch to several feet, composed of sandstone, greenish slate and limestone. The divide between the head of the Moosyie and the Kootenay is not over 600 feet above the former.

In descending to the Kootenay the country again becomes open, gently undulating table-land, with gradual slopes, and grassy spots on the hills. At the foot is a prairie of some extent, level and surrounded with lacustrine terraces and low-timbered hills, from which the first view opened of the Rocky Mountains.

The range seen from here is that which separates the Kootenay from one of its branches, known as Elk River. It is steep and rugged, with crests of bare rock, and des-

titute of timber, and the lines of stratification are visible from the western bank of the river.

Snow was seen only in patches (August 21st), though the higher points were some 8,000 or 9,000 feet above the sea.

The soil at Joseph's Prairie, so called from its Indian owner, is good, but very wet in the spring. We saw here some patches of wheat, which looked well for Indian cultivation. The natives had a large band of horses and cattle, including cows, which they milked.

The route hence down the Kootenay at first ran some distance back from the river, in a sort of lateral valley, dotted with ponds and small lake-basins, but afterwards approaching the bank more nearly, as the country became broken. The same general character of rock prevailed throughout, greatly disturbed, and dipping in various directions. Eruptions of trap and porphyry have, in places, broken through them.

The valley of the Kootenay, in the neighborhood of the parallel, is of considerable width, but of very irregular surface, as indicated by the accompanying profile, constructed by Mr. Hudson.

On the western side, a series of parallel ridges rise gradually in succession to the base of the mountains. They appear to have once constituted a series of terraces, resting upon outcrops of rock, which have been eroded by currents in the direction of the stream. On the eastern side of the river, the country is more open and less disturbed, but with some of the same features.

Between the parallel and the mouth of the Akonoho are quite extensive level plateaux, terraced, constituting the Tobacco plains, so called, if the name can really be given to anything but a small patch. It is said to have been originally on a small tract of land near the Hudson's Bay trading post, on which some tobacco was once planted; as generally applied on the maps, it is simply absurd.

There is, throughout, very little land available for tillage, the terraced country being sandy or gravelly.

The Indians of the neighborhood raise some wheat, turnips, potatoes, and parsnips, generally selecting recesses of the foot-hills, or other favorable spots. Bunch-grass covers the open country, and the grazing is very good.

As at Joseph's Prairie, we found the natives in possession of numerous horses and some very good cattle.

The terraces bordering the Kootenay here are distinct, two, or sometimes three, in number, and reach a height of 600 feet. The highest are generally modified, and far from continuous.

Terraced slopes, in some instances, run up into the recesses of the mountains to a much greater height. Mr. Hudson counted, on one of these, fourteen different levels.

KOOTENAY RANGE.

The valley of the Akonoho is quite wide near its opening into the Kootenay, and, like that of the latter, terraced, the plateaux extending up it to an elevation of 4,000 feet above the sea. Ascending the stream, the pass narrows, and is shut in by mountains. The summit is about 5,200 feet. In the lower valley the rocks were chiefly sandstones, with some slate, in some places rendered metamorphic by the intrusion of trap. Upon the summit they were a red micaceous sandstone and red shale, interstratified with green slates. These latter are sometimes glazed on the surfaces of lamination, sometimes separated by their partings of mica, and occasionally are calcareous.

Ripple-marks and sun-cracks are abundant and exceedingly distinct. Another class of marks, frequently seen, is of parallel lines sharply cut, as if with a graver's tool, and sometimes crossed at right angles, but of inconsiderable depth. They probably indicate that joints had

commenced to form. Descending on the east side, the sandstones prevail for some distance down; and among the fragments rain-marks, and some very obscure forms, conjectured by Dr. Newberry to be fucoids, were abundant.

These rocks were succeeded by limestone, which forms in one place a precipitous wall of 700 feet in height above the creek. At the foot of this the first distinct organic remains were seen in a species of coral zaffrenites, and a little farther a number of casts were collected of spirifer, athyris and productus.

All these were found in loose fragments of limestone, and, although their neighboring origin was unquestionable, none were detected actually in place. An examination by Mr. Meek refers them, without doubt, to the carboniferous period, as will be seen by his report; but their exact place in the series is uncertain.

No traces of coal or coal-plants were discovered. Lower down the stream, and apparently below the limestone which contains these fossils, is an outcrop of sandstone, said by Dr. Newberry to be the exact counterpart of the Potsdam sandstone, as it occurs farther south in the Rocky Mountain ranges.

As regards the dip of these rocks, taken as a whole, no general rule could be ascertained. They are horizontal, or nearly so. At the summit they dipped N. E. 25°, and elsewhere they are inclined in various directions. The upheaval of the range is undoubtedly from the eastward, but there seem to be several foldings. The red sandstones and slates appear to overlie the limestone.

The valley of the Akinesahtl, or Upper Flathead River, near the parallel, though of some width, has no interval land, being occupied almost entirely by the terraces. The uppermost of these consist, instead of rolled gravel, almost entirely of angular fragments, the débris of the adjacent hills.

The first view of the eastern range of the Rocky

Mountains, as presenting itself on emerging from the pass into the valley of the Flathead, is that of a number of detached masses rising above a line of foot-hills. These are, in fact, the ends of spurs or ridges which break off from the watershed, or in some cases of almost isolated groups. The highest points of this range, which here are about 10,000 feet above the sea, are not upon the divide, but upon these outliers. Their general shape is ragged and precipitous, with sharp crests or points. Their altitude, their striking forms, and the various colors displayed in the rocks which compose them, unite in these mountains the highest elements of beauty and grandeur.

The pass through this range leads up a creek which heads, in the main divide or watershed, with one of the feeders of Belly River, the southern branch of the south fork of the Saskatchewan. Two remarkable mountains,—Kisheneton, on the north, and Kishenehu, on the south, the latter a double peak,—form its western portals. The general material of these mountains is, on the western side of the range, sandstones and shales of various colors, from yellow to deep-red, greenish slates and limestone.

Mr. Alden, who ascended one of the peaks, describes the alternations as follows: The base was covered with débris to the estimated height of 1,500 feet above the level of the creek, where the rock was red sandstone. Over this was a belt of the same rock, metamorphic, and in waved or contorted strata, 150 feet thick, succeeded by 500 feet of green slates and red sandstones interstratified; then again by red sandstones 500 feet, the summit, to a thickness of 1,500 feet, consisting of an ochre-yellow earthy shale.

The other peak of the same mountain, on the contrary, was of a light-drab sandstone at the base, and above composed of green and red strata to a thickness of 600 feet, and then of red sandstone to the summit.

The foldings, or plications, of the strata through this

range are evidently on a vast scale, and it would be idle to attempt unravelling them in a single and hurried passage. As a general thing, it appeared to me that the limestones occupied the lowest position, and the earthy red and yellow shales and sandstones the highest.

In ascending the pass, I found a thick bed of trap and greenstone porphyry, intercalated between strata of sandstone, upon one of the mountain-sides, and elsewhere noticed curved and contorted strata, evidently the result of other intrusions. Ripple-marks were everywhere abundant. I met with no fossils; but at Camp Akaminia, on the southern fork of Kishenehu Creek, Mr. Hudson discovered the singular impressions figured by Dr. Newberry, which cover large slabs of rock. Their character, however, is not sufficiently determined to afford any indication of the age of the foundation. Low terraces bordered the valley almost to the foot of the divide.

The summit, or watershed proper, is here continuous for at least several miles, and its dip is uniform to the S. S. W., or perpendicular to the trend of the range, in which direction it presents a gradual slope, while to the N. N. E. it plunges at once into the valley. The elevation is about 6,000 feet. A few stunted pinus contorta and balsam firs only grow on the summit, but their diminished size seems to be owing to scanty soil and exposure to wind, as they reach a height at least 500 feet greater on the adjacent mountains.

The divide is but narrow, and the view to the west extended down the valley of the Kishenehu to the Flathead, and on the east through the gorge of another creek to that of a larger stream, of which it is a feeder.

It embraced, on either hand, a vast area of mountains of the most picturesque forms, and singular for their variety of coloring and the linear marks of stratification.

Several glaciers lie upon the summits of the higher peaks, the most conspicuous of which, on Mount Kintla, is apparently some two miles in extent.

No valley glaciers exist so far south as the forty-ninth parallel.

Descending the pass to the eastward, the mountains rise on either side with steep slopes of débris, crowned by precipices.

Greenstone was mixed with the boulders in the stream, and large masses lay scattered through the ravine. Its origin I could not trace.

The stratification of the other rocks was but little affected; but it was, in many places, metamorphic. Limestone prevailed to a much greater extent than west of the divide, apparently beneath the sandstones; and, towards the foot of the pass, quartzite seemed to underlie that also.

Emerging from the gorge of the creek, between two remarkable and precipitous cliffs, the pass enters a small valley, terraced, and with fine grass. Its course was at first southerly, and then eastward for about three miles, when it opened at once upon the plains of the Saskatchewan. On the north, the mountains here terminate abruptly, rising at once in steep, rocky declivities from the prairie. Southwards, an outlier is separated from the main range by a long, narrow and very picturesque lake, the waters of which also enter Bow River. The elevation of this is about 4,000 feet above the sea.

Terraces run along the eastern base of the mountains, from fifty to seventy-five feet above the creek. No timber is visible, except in the bottom, where there were stunted aspen and poplar, willows, and the service berry; and thus suddenly does the scene here change from the mountains and forest of the Pacific to the vast, treeless, and almost level expanse of the central region.

On so imperfect an examination of these great mountain-ranges, and without fossils, from numerous localities, it would be presumptuous to attempt any positive establishment of their geological age, or to unravel the complications of their structure. No crystalline or even true

hypozoic rocks were seen in place in the two eastern ranges, upon which to found a basis of reasoning.

The opinions arrived at, from such study as I was enabled to make, are chiefly conjectural. A much better judgment could be formed on a route from east to west than in the contrary direction, as means of comparing their lithological character, at least, with known formations, could thus probably be found.

I suppose the range crossing the Kootenay, at the falls, and continuing northward through its great bend, which I have termed the Moosyie range, to be azoic, and that the quartzites and highly quartzose sandstones of the Kootenay and watershed ranges are also of that formation.

The existence of carboniferous rocks in the Kootenay Range has been shown, and it is highly probable that both the Silurian and Devonian systems are embraced between that and the azoic, while the earthy shales which crown the water-shed are probably triassic.

From Tobacco Plains to Chelemta.

Descending the Kootenay River from the parallel, the valley narrows, and rocky escarpments occasionally show on either side. The route led down the left bank as far as the great bend of the river, sometimes over elevated terraces, sometimes over broken country covered with slides from the mountains.

The general dip here seemed to be to the N. E., often at a very low angle. Limestone formed the material of some of the bluffs, and in one place I noticed it smoothed and worn, as if by the action of water. Crossing to the right bank, no general dip could be detected. Ripple-marks and sand-cracks were observed in abundance as far down as the falls.

The falls of the Kootenay occur at its passage through the range of mountains which I have assumed as the continuation of the Bitter Root range. The bed-rock

here dips easterly, at an angle of apparently five or ten degrees, the water rippling over the edges of the fractured laminæ; and then the main body, sweeping diagonally across to the right, plunges into a chasm, producing a very pretty effect. The river, for some distance below, is cañoned.

The rocks are of the same character as above, but metamorphic and greatly contorted. Against the western side of the mountains lie terraces elevated some 300 feet above the river, and apparently stretching back for some distance. At the crossing of the Yakh, a very tough hornblendic rock appears, for the first time, among the boulders, probably underlying the others.

Approaching Chelemta, the bottom widens out into flood-lands, and the terraces reach a height of 700 or 800 feet above the river. The rock there, as before mentioned, is granite.

SPOKANE RIVER TO THE DALLES.

The great plateau inclosed between the Spokane, Columbia and Snake rivers, and extending eastward to the base of the Cœur d'Alêne and Bitter-Root mountains, is composed entirely of basalts and lavas, overlying granite, which is visible on its northern skirt in the bluffs bordering the Columbia.

Its surface is greatly broken and intersected by coulées and cañoned valleys. The most noted of these, the Grand Coulée, was not on the route of the party. It has been described by Lieut. Arnold, U. S. Army, in volume 1 of the Pacific Railroad Reports. No timber is found on these plains, except along the northern skirt of the Grand Coulée. The soil is generally thin and poor, without arable land, though there are tracts of good grazing; but the exposure to winds and the depth of snow compel the withdrawal even of the Indian horses to more sheltered situations during the winter.

The plateau seems to have been formerly covered with drift to a considerable depth, of which remains exist in some rolling country on its northern edge, and elsewhere in low table-topped hills, but the greater part is almost wholly denuded.

Basaltic walls, rising in steps, line the cañons, and here and there crater-like basins and rifts on the surface indicate the sources from which the lava was emitted.

As a general thing, the upper beds are more vesicular and less massive than the lower, and the columns and nodules smaller. The lower form large irregular blocks and large pillars, often shaly in structure. Throughout all this country the general position of the beds is apparently horizontal. The elevation of the plateau is, at the crossing of the Spokane River, about 2,500 feet above the sea, whence there is a gradual falling off southward to the Snake River.

The mountainous country lying west of the Spokane plains, or between the Columbia and the Cascade range, was described in my report to Capt. McClellan in 1853, and was not revisited by the expedition.

Below the Winatsha or Pisquous, the rocks are exclusively volcanic, basalts and lavas, over which, in places, lie thick beds of tufaceous deposits and infusorial earths. Some of them are described in the accompanying report of Mr. Edwards. All which have been examined prove to be, as indicated by Professor Bailey, of fresh-water origin.

South of the Columbia, the high basaltic plateaux continue intersected by the valleys of the streams emptying into it, of which those of the Des Chutes and Mahagh, or John Day's River, are the principal.

The former has been fully described by Dr. Newberry in his report to Lieut. Williamson, and will serve as a type of the whole. Between the Snake River and Fort Walla Walla, however, the basalt does not attain the usual elevation, but is only visible in the ravines.

The country is there a sea of rolling hills, which in their uniform height and contour, and the color imparted to them by the bunch-grass, resemble the sand dunes thrown up on coasts, though they are much more eroded.

The valley of the Walla Walla is here broad and level, the general soil sandy, like that of the hills, but along the streams there is a very productive black mould. All sorts of vegetables thrive well, and Indian corn ripens; but, from the limited extent of first-class land, it is better suited to gardening and grazing than to farming. The lower part of the valley is sterile and worthless.

The route down the Columbia from the Snake is a picture of desolate grandeur. High basaltic bluffs, or hills of drifting sand, destitute of trees, wall it on either side. The shores are lined with black reefs of basalt, their surfaces ground by the passage of ice, or the wear of the sandy waters in the freshet. The course of the river is broken by rapids, which are not, however, impracticable to light-draught steamers, but below the mouth of the Des Chutes a perpendicular fall of ten or twelve feet effectually bars passage, as does also the shoot at the Dalles. From these to the Cascades, the stream is deep and still. This last obstruction is obviously recent, and caused by a slide of rocks from the mountain, which has dammed back the water, overflowing its banks and submerging skirts of timber, the stumps of which are still visible beneath the surface.

Several members of the party, on the conclusion of the survey, ascended the Snake River in a small steamer from Walla Walla to the mouth of the Kooskooskie, and that stream to its first forks, about forty miles.

Gold had recently been discovered in the mountains forming the western series of the Bitter-Root range, and the influx of miners into what has since proved a very productive country had already commenced.

The metal has since, it is reported, been also found in

Burnt and Powder rivers, which drain into the Snake, from the eastern side of the Blue Mountains.

The country lying on either side of the Snake has been almost entirely unexplored, nor has any survey been made of the river itself between the mouth of the Kooskooskie and the Malheur, a distance of two degrees and a half of latitude. The formation is everywhere basaltic, and of the most desolate and forbidding character.

The Snake pursues its foaming course through a cañon which attains from 1,000 to 1,500 feet in depth, the walls resembling, though on a far grander scale, the Palisades of the Hudson; on either side, a steep talus of fragments being surmounted by a vertical precipice of black rock.

Standing on the brink, the eye sweeps a vast plain yielding no other vegetation than the artemesia and its associated shrubs, and sees the windings of this great excavation narrow, in the distance, to a line.

Here are some of the grandest features of natural scenery on the continent. The "American" and "Fishing" falls have been described by various travellers; but, as the usual trails avoid the river in places, others, and among them the Shoshone Falls, second to Niagara only in volume, and possessing features to which that can lay no claim, have escaped notice.

Crossing the country in 1849, I was one of the first party, Indians and trappers excepted, who ever visited them. They are situated eight miles above Rock Creek, or about 100 miles below Fort Hall. The river here bends round a vast isolated mass of basalt, and falls, by two or three cascades, into a wide and still basin, pausing, as it were, before it takes its final and unbroken plunge. So deep is the chasm in which it flows that the sound of its fall is barely heard upon the level of the plain.

We led our horses, by a steep and difficult path, to the margin of the basin, and thence succeeded in reaching the river at its foot. The height we calculated, by the cedars

which cling to the crevices of the rocks, at 180 feet; its width was estimated at 200 yards. The rock over which it poured was of argillaceous porphyry, upon which rested the basalt of the desert.